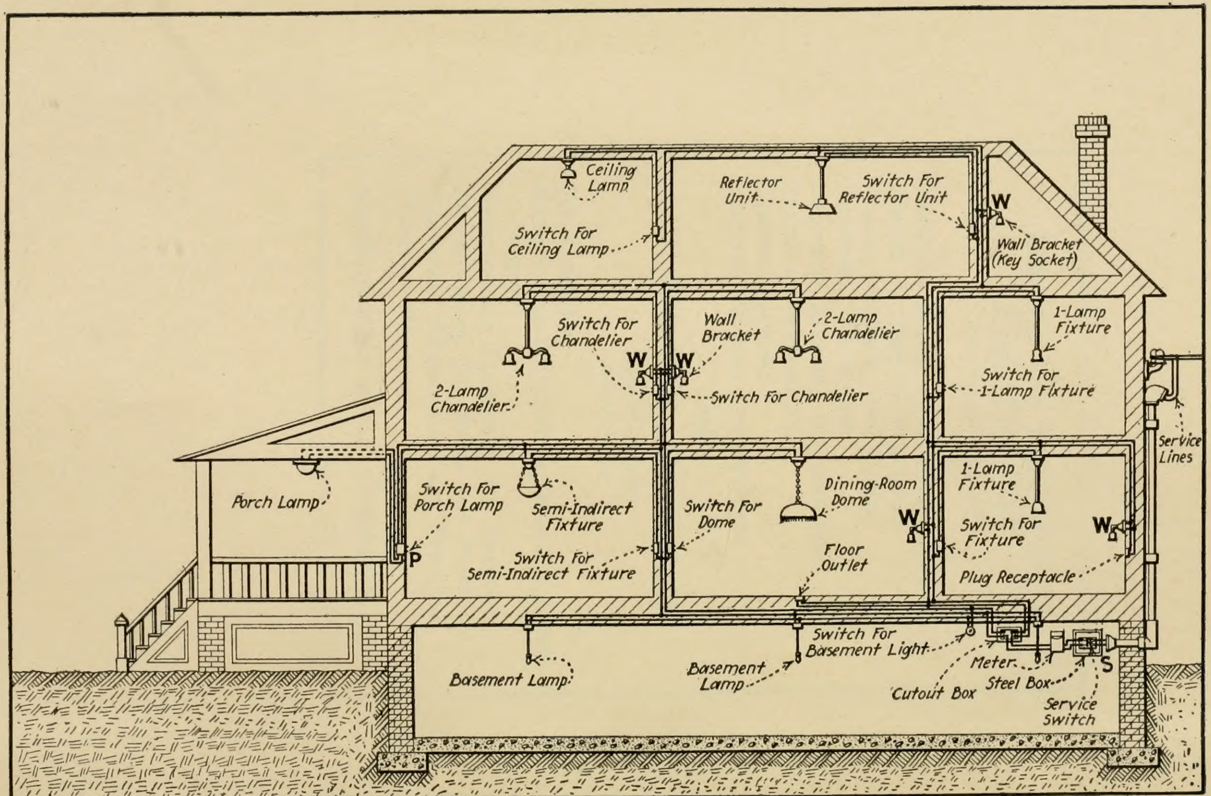
LIGHTING CIRCUITS AND SWITCHES



Frontispiece.—Typical lighting circuits and controlling switches for a small residence. (Service-switch, *S*, and switch, *P*, for porch-lamp are double-pole switches to comply with N.E.C. Rules 24*a* and *c*. All other switches are single-pole switches. Wall lamps, *W*, are controlled by key sockets. In an actual installation the meter feeds from left to right, whereas herein, for purpose clarity it is shown as feeding from right to left.)

LIGHTING CIRCUITS
AND
SWITCHES

BY

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PREFACE

LIGHTING CIRCUITS AND SWITCHES has been prepared to satisfy the demand for a practical reference book on this subject. It shows and discusses those circuits and connections, and their applications, a knowledge of which is, at some time or other, required by practically every man who is in any way concerned with electric lighting. Although the simpler circuits and their descriptions have been included, the important function of the book is to record diagrams and explanations of the more complicated circuits and control methods—with which relatively few men are familiar and which are, in any case, easily forgotten.

This information has been collected from many sources. Most of it is from the author's personal notebook and data files which have been accumulated during an extended period. Some has been furnished by switch and apparatus manufacturers. Practical electrical workers, teachers, engineers in our own and other organizations and many others have all contributed.

Throughout, the policy has been to endeavor to convey with pictures the necessary information to the reader. It follows therefore that the work consists largely of diagrams and drawings of the different circuits, switches and switching methods. These have, where feasible, been so rendered as to be self-evident. But, in addition, they have been supplemented with explanatory text.

The material relates almost wholly to electric-lighting circuits and switches, for interior building applications, operating on low-potential (less than 600 volts) systems. Most of the matter concerns 110–220 volt, *two-* or *three-wire systems*. Some data which relates to electric-heating circuits and switches has been included. The principal NATIONAL ELECTRICAL CODE rules, which concern the subjects under discussion, are interpreted in the proper places. How to comply with these CODE rules is explained.

Certain of the circuits and diagrams have no direct practical application—they are shown to illustrate principles. These principles and the ideas which they will suggest can often be effectively employed in the solution of unusual circuit-control problems.

In the opening divisions of the book, the different circuit components, such as circuit elements, switches and similar appliances are defined and explained. Then, those NATIONAL ELECTRICAL CODE rules which apply are discussed. This introductory material is followed by the divisions which treat the circuits of the different types such as *Single- and Multi-pole Switch Circuits, Three- and Four-way Switch Circuits, Master or Emergency Circuits, Electrolier and Heater Switch Circuits* and *Remote-controlled, Door and Time Switch Circuits.*

The closing division discusses *Theatre Lighting Circuits* and includes a complete specification for the electric lighting of a modern theatre. Theatre-lighting control has, of late, become a subject of considerable importance and complexity. This is because of the exacting requirements for theatre-lighting installations which are now enforced by the producers, the public and the NATIONAL ELECTRICAL CODE. The producers and the public demand the most-comprehensive color and lighting effects, which involve rather-intricate and expensive lighting circuits and switching and dimming equipment. The CODE insists that the fire hazard be a minimum. Both of these aspects have been treated carefully.

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Mutual Electric & Machine Co.
Trumbull Electric Mfg. Co.
Automatic Switch Co.
Paragon Electric Co.
Mercury Time Switch Co.
The Brookins Co.
Sundh Electric Co.
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Hart & Hegeman Mfg. Co.
Beaver Machine & Tool Co.
Connecticut Electric Co.
General Electric Co.
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Other acknowledgments have been made throughout the book. If any has been omitted, it has been through oversight, and if brought to the author's attention, it will be incorporated in the next edition.

CONTENTS

LIGHTING CIRCUITS AND SWITCHES

DIVISION I

CIRCUIT AND SWITCH NOMENCLATURE

1. Circuit And Switch Nomenclature Should Be Thoroughly Understood before proceeding with the study of circuits and switches. Accordingly, different circuit components and various classifications and types of switches which may be employed in an electric-light wiring interior installation are defined in the following sections. These definitions are in conformity with the generally-accepted meanings of the words.

2. An Electric Circuit Is Defined (Fig. 1) as the complete path of an electric current including, usually, the generating

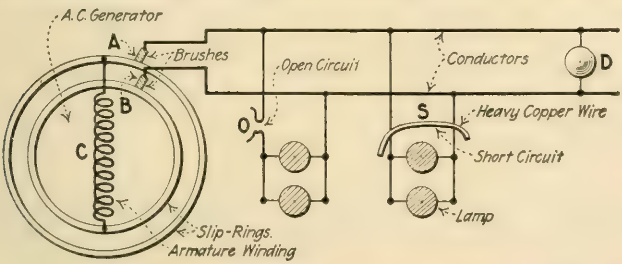


Fig. 1.—Illustrating various electrical circuits. (Closed circuit; *CBDAC*. External circuit, *BDA*. Internal circuit, *ACB*. Open circuit, *O*. Short circuit, *S*.)

device; also, by extension, any portion of such a path. The complete path is often spoken of as a *closed circuit*. When its continuity is broken so that a current can no longer pass, the circuit is then said to be an *open or broken circuit*. An *external circuit* (Fig. 1) is that portion of the complete circuit external to the source of energy. An *internal circuit* (Fig. 1) is that portion of the circuit which is within the source of energy.

Note.—A Short-circuit (Fig. 1) is said to exist when two sides (Sec. 11) of an electrical circuit which are at different potentials are connected, one to the other, by a conductor of relatively low resistance.

3. A Feeder, or feeder circuit, (*F*, Figs. 2 and 3) is a set of conductors, in an electrical-energy distributing system, which extends from the original source of energy in the installation

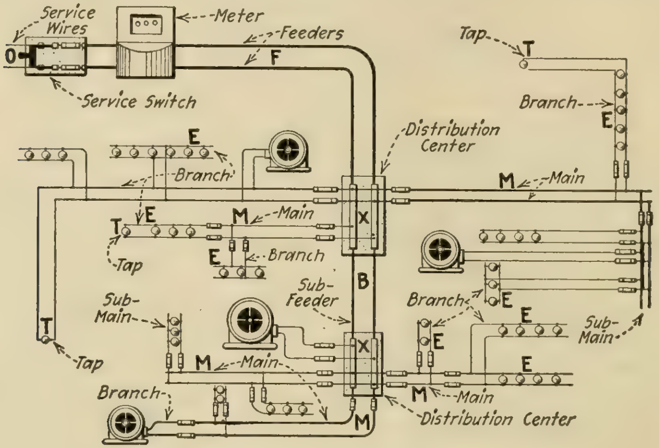


FIG. 2.—Illustrating circuit nomenclature.

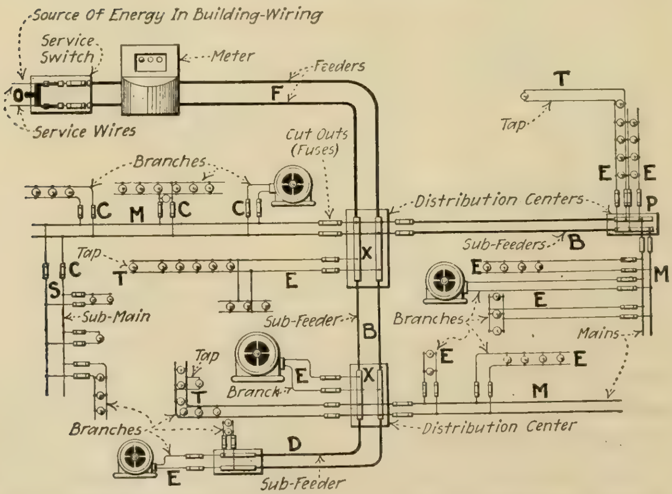


FIG. 3.—Circuit-nomenclature change by changing distribution centers and cutouts.

to a distributing center and which has nothing connected to it between the source and the center. The source of energy

may be a generating or a sub-station, or, in the case of building or house wiring, it may be a connection (*O*, Fig. 2) to the service conductors from the street.

4. A Sub-feeder, (*B*, Figs. 2 and 3) is an extension of a feeder, or (Fig. 3) of another sub-feeder, connecting one distribution center to another, and having no other circuit connected to it between the two distribution centers.

5. A Main (*M*, Figs. 2, 3, and 4) is any supply circuit to which other energy-consuming circuits (sub-mains, branches, or services) are connected through automatic cutouts (fuses or circuit breakers) at different points along its length and which has no cutouts in series with it in its entire length.

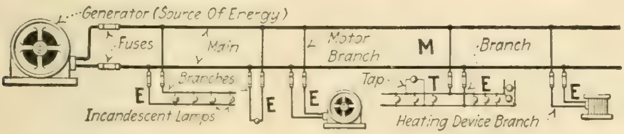


FIG. 4.—Showing a main feeding direct from a generator. (No feeder in circuit.)

NOTE.—WHERE A MAIN IS SUPPLIED BY A FEEDER, the main is frequently of a smaller-diameter wire than is the feeder which serves it. An energy-utilizing device is never connected directly to a main; a cutout always being interposed between the device and the main.

6. A Sub-main (*S*, Fig. 3) is a subsidiary main, fed through a cutout from a main, or from another sub-main, to which branch circuits are connected through cutouts. A sub-main is usually of smaller wire than is the main or other sub-main which serves it.

7. A Branch, Or Branch Circuit, (*E*, Figs. 2, 3 and 4) is a set of conductors which is fed through an automatic cutout (from a distribution center, main or sub-main) and to which one or more energy-consuming devices are directly connected, without the interposition of additional cutouts. The only cutout associated with a branch is that through which the branch is fed at the main, sub-main, or distribution center.

8. A Tap, Or Tap Circuit, (*T*, Figs. 2 and 3) is a circuit serving a single energy-utilizing device which is connected directly to a branch without the interposition of a cutout.

9. A Distribution Center, (x, Figs. 2 and 5) (also sometimes called a *distributing center*) in an electrical-energy-distribution system, is the location at which a feeder, sub-feeder, main or sub-main, connects to the subordinate circuits which it serves. The switches and automatic cutouts (fuses) for the control and protection of the sub-circuits are, usually, grouped at the distribution center. In interior-wiring parlance, a distribution center is often an arrangement or group of fittings whereby two or more minor circuits are connected at a common location to another larger circuit. A panel box or a group of porcelain cutouts is a distribution center; see Fig. 5.

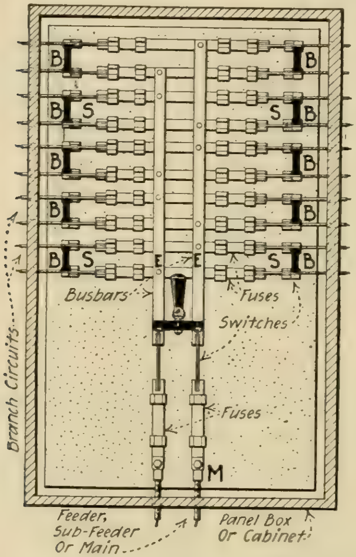


Fig. 5.—A distribution center.

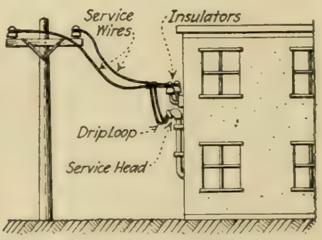


Fig. 6.—Illustrating definition of a *service*.

10. A Service, Or A Service Connection, (Fig. 6) is a set of conductors constituting an overhead or an underground connection between conductors in a thoroughfare (as a main belonging to a public service corporation) and those of an interior or isolated wiring system. A service serves the wiring system with energy.

Note.—Circuit Nomenclature Is Governed To A Considerable Extent, By Distribution Centers And Cutouts. Compare Figs. 2 and 3. By omitting, the distribution center at P, Fig. 3, the sub-feeder B of Fig. 3 is thereby changed to a main. By omitting the cutouts, C, Fig. 3, the main becomes a branch; and the sub-main is changed to a tap.

11. A Lead, A Leg, Or A Side, Of A Circuit may be defined as any part of either one of the conductors between the source of electrical energy and any energy-consuming device.

EXAMPLE.—A LEAD is illustrated in Fig. 7. In ground-return circuits, the earth is considered to be one side of the circuit. In an automobile lighting and ignition system which employs a "one-wire" circuit, the metallic frame of the chassis is termed a lead. The meaning of the terms lead, leg, and side are synonomous and are used interchangeably.

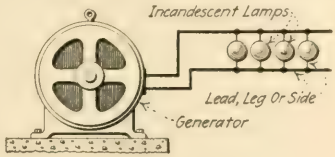


FIG. 7.—Illustrating meaning of lead, leg, or side of an electrical circuit.

12. A Side Circuit, which is a term applied to a three-wire-neutral system, is a circuit comprising one outside or potential wire, the neutral conductor, and the receivers connected between them. The neutral may, or may not be grounded. Thus, every three-wire-neutral system has two side circuits (*AON* and *NPB*, Fig. 8).

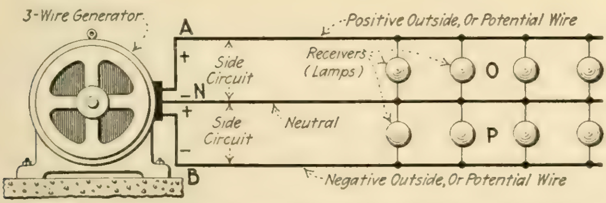


FIG. 8.—Direct-current, three-wire system. (In a single-phase alternating-current, three-wire system, the polarities of the outside wire change from instant to instant as the current alternates in the direction. But at the instant shown one outside wire is negative the other outside wire is positive.)

13. A Phase-wire is any one of the conductors of a polyphase alternating-current circuit.

NOTE.—"PHASE" IS A TERM WHICH IS FREQUENTLY ERRONEOUSLY APPLIED to a phase-wire. Strictly speaking, the term *phase* when used in alternating-current terminology refers to time.

14. A Traveler May Be Defined (Fig. 9) as: Either of the conductors (wires) which connect together two switches (such as two three-way switches, or a three-way and a four-way switch, Div. 5) and which do not directly connect to an energy-consuming device, nor to a conductor on which a voltage

normally exists. In the usual installation, only one of the travelers connecting any two switches carries current at any one time.

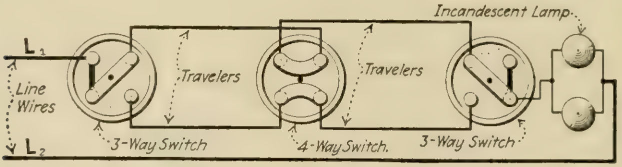


Fig. 9.—Illustrating meaning of traveler.

15. Restricted Control of a lighting circuit is a control such that only one lamp of two or more lamps which are all on the same branch circuit—or only one group of lamps of two or more groups which are all on the same branch circuit—can be lighted at any one time.

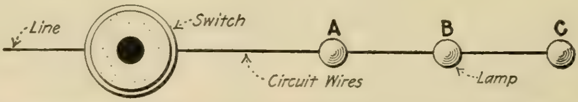


Fig. 10.—Single-line diagram—one line represents all of the wires of a circuit to illustrate definition of "restricted control." (Only one of the lamps, *A*, *B*, or *C*, can be lighted at any one time.)

Explanation.—That is (Fig. 10), restricted control permits that only lamp *A*, lamp *B* or lamp *C*, can, at any one time, be lighted.

16. Selective Control of a lighting circuit is a control such that all possible combinations of two or more lamps, or two or more groups of lamps, on the same branch circuit may be lighted simultaneously.

Fig. 11.—Single-line diagram to illustrate meaning of "selective control." (Selective control is provided if, *S*, enables each of the following combinations to be obtained at any one time: All lamps off; all lamps on; *A* off, *B* and *C* on; *B* off, *A* and *C* on; *C* off, *A* and *B* on; *A* and *B* off, *C* on; *A* and *C* off, *B* on; *B* and *C* off, *A* on. These are all of the possible combinations for three lamps.)

Explanation.—That is (Fig. 11) selective control is provided by the switch if the connections are such that each of the following combinations may be obtained at any one time: (1) All lamps off. (2) All lamps on. (3) *A* off, *B* and *C* on. (4) *B* off, *A* and *C* on. (5) *C* off, *A* and *B* on. (6) *A* and *B* off, *C* on. (7) *A* and *C* off, *B* on. (8) *B* and *C* off, *A* n.o

17. Restricted-selective Control of a lighting circuit is a control of two or more lamps, or groups of lamps, on the same branch circuit by some arrangement which enables more than one lamp, or group of lamps, to be lighted at one time but does not provide for all of the possible combinations. It is therefore something between restricted control (Sec. 15) and selective control (Sec. 16).

EXPLANATION.—Restricted-selective control may be said to obtain when the connections are such (Fig. 12) that at any one time, only: Lamps A and B may be lighted with C off; all lamps may be lighted; all lamps may be turned off. It should not be assumed that this is the only combination obtainable with three lamps or three groups of lamps, which

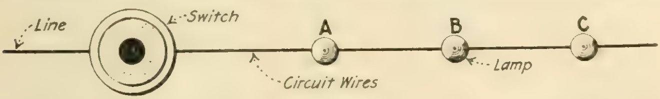


FIG. 12.—Single-line diagram to illustrate definition of restricted-selective control. (Connections are such that only the following combinations are available; A and B lighted, C off; all lamps on; all lamps off.)

can properly be termed restricted-selective control. Any sequence of any combination of two or more lamps which is not strictly restricted control (Sec. 15) or selective control (Sec. 16) is restricted-selective control. Restricted-selective control is also sometimes called *electrolier control.*

18. A Switch May Be Defined as: A device which is primarily designed for making (closing) and breaking (opening) electric circuits.

19. Symbols Of The Various Types Of Those Switches And Energy-consuming Devices which are most frequently used in the wiring diagrams contained in this book are shown in Figs. 13 and 14.

20. Electric Lighting Switches May Be Classified In Accordance With Four Different Characteristics (see Table 21): (1) *Blade mechanism.* (2) *Operating method.* (3) *Mounting design.* (4) *Circuit connections.* Table 21 indicates how these various classifications interrelate in commercial electric lighting switches. All of the terms used in Table 21 are defined in subsequent sections. Also certain other switch-parlance terms, which are used in commercial catalogues and literature but which cannot logically be shown in the table, are also hereinafter defined.

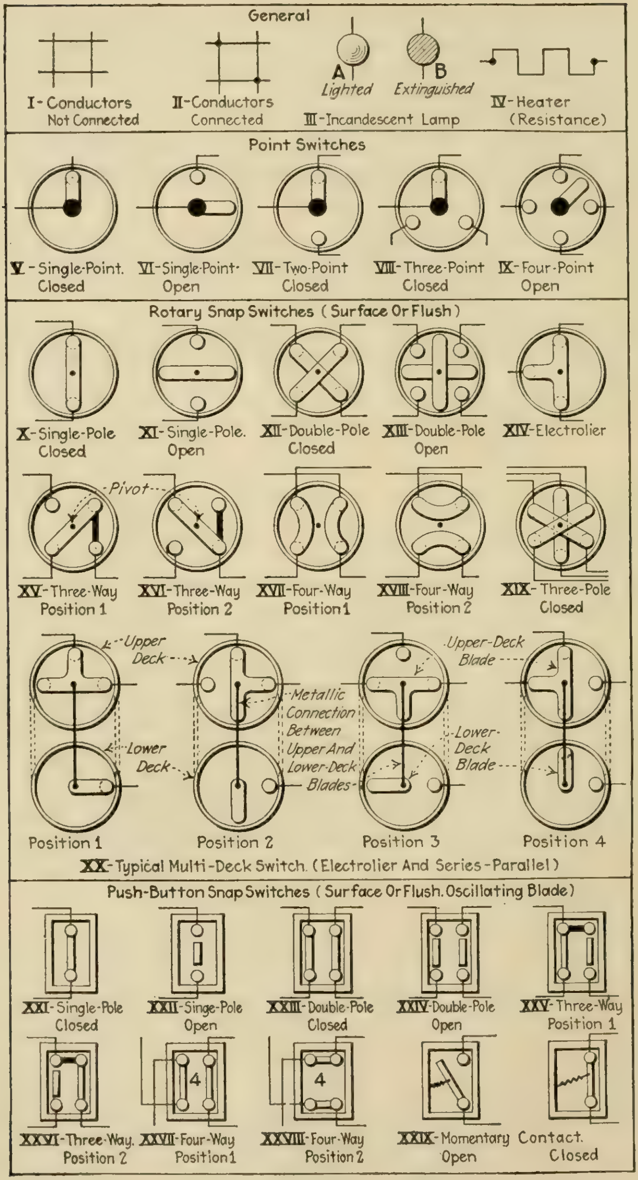


Fig. 13.—Wiring-diagram symbols.

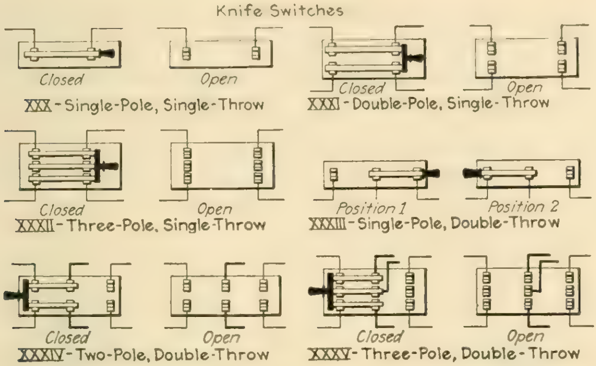


FIG. 14.—Wiring diagram symbols. (Continued from Fig. 13.)

21. Table Showing Classification Of Electric Lighting Switches. (Tabulating switches of different types as they are manufactured.)

Blade mechanism	Operating methods	Mounting design	Circuit connections
Revolving blade	Rotary-button	Surface, flush.	1-, 2-, and 3-pole; 3- and 4-way; electrolier; and series-parallel.
	Push-button.	Surface, flush, pendent, straight-through.	1-, and 2-pole; 3- and 4-way; electrolier; series-parallel; and momentary contact.
	Pull.	Surface, flush, pendent.	Same as above.
Oscillating blade	Toggle-lever or tumbler.	Surface, flush, pendent.	Same as above.
	Push-button.	Surface, flush, pendent.	
		Straight-through.	1-pole.
Knife blade.........	Knife-handle.	Surface.	1-, 2-, 3-, and 4-pole, single- and double-throw.
Lever blade.........	Rotary-button, knife-handle.	Surface.	1-, 2-, 3-, and 4-point, etc.
Reciprocating blade..	Push-button.	Surface, pendent.	1-pole.

22. Electric Lighting Switches May Be Further Classified As To Blade Mechanism into: (1) *Revolving-blade switches.* (2) *Oscillating-blade switches.* (3) *Knife-blade switches.* (4) *Lever-blade switches.* (5) *Reciprocating-blade switches.*

23. A Revolving-blade-mechanism Switch Is Defined, (Fig. 15) as the term is used in this book, as a switch the con-

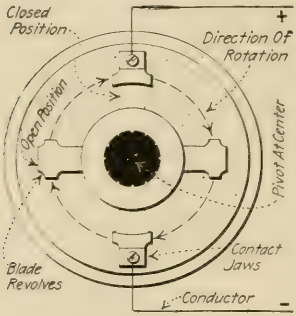


FIG. 15.—Illustrating operation of revolving- (rotating-) blade switch.

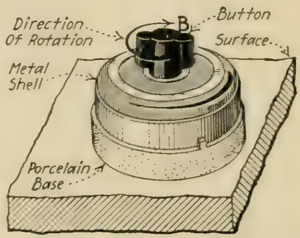


FIG. 16.—Rotary surface "snap" switch.

tact blade or blades of which are pivoted at their centers and when operated turn always in the same direction. The ordinary surface "snap" switch (Fig. 16) affords an illustration of this type of blade mechanism.

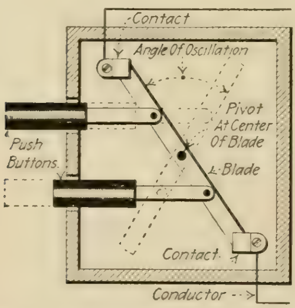


FIG. 17.—Illustrating definition of oscillating-blade switch mechanism.

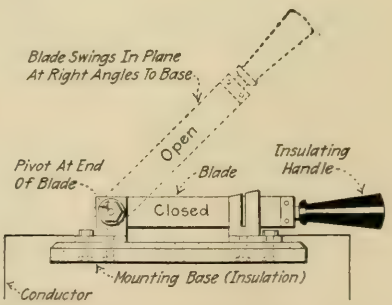


FIG. 18.—Illustrating definition of knife-blade mechanism switch.

24. An Oscillating-blade-mechanism Switch Is Defined (Fig. 17) as one, the blade or blades of which are pivoted on a central axis located midway between the blade ends and which are oscillated in a plane at right angles to the axis when

the switch is operated. Many flush push-button switches employ blade mechanisms of this type.

25. A Knife-blade-mechanism Switch Is Defined (Fig. 18) as one the contact blade (blades) of which is (are) pivoted at one end on an axis (common axis) and swings (swing) in a plane (planes) perpendicular to the mounting base of the switch. The blade of a knife-blade mechanism switch is hinged at one end like the blade of a jack-knife. The ordinary knife switch (Fig. 18) illustrates this mechanism.

26. A Lever-blade-mechanism Switch May Be Defined as one the blade of which is so pivoted at one end that, when

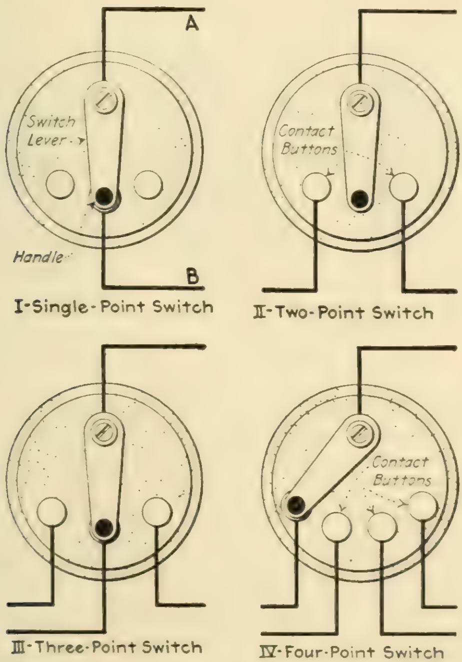


FIG. 19.—Single-point, two-point, three-point and four-point switches.

the switch is operated by the handle at the other end, this handle-end swings in a circle in a plane parallel to the base and contacts with buttons or jaws located on the circumference of the circle. See Fig. 19. The one-, two-, three- and four-point switches employ blade mechanisms of this type.

27. A Reciprocating-blade Mechanism Switch (Fig. 20) is one the blade of which is shifted to and fro longitudinally in a straight line when the switch is operated.

Explanation.—In The Reciprocating-blade Switch Mechanism, Fig. 20, the cylindrical "knob," K, is integral with the metal button, M, so that when M is pushed in or pulled out, K moves with it. The spring, S, is an ordinary coil spring which has its two ends tied together, so that it is in the shape of a ring. This ring-shaped spiral spring encircles, and its inner circumference always presses against the cylindrical surface of K. At I, the spring, S, being under tension, tends to contract—decrease its diameter—and thereby forces K to the right and holds the blade, B, in the position shown. The blade B is not attached to K.

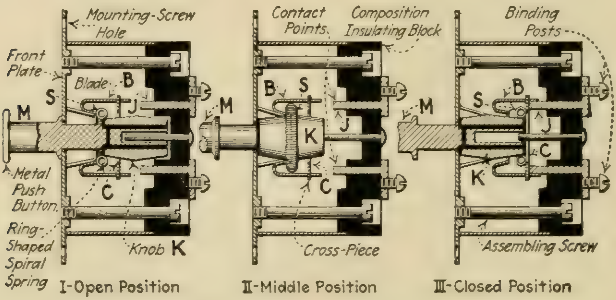


Fig. 20.—Reciprocating-blade-mechanism switch for automobile lighting. (*Cutler Hammer Mfg. Co.*)

At II, M has been pulled outward to the middle position. The barrell-shaped knob, K, having been pulled through the spring, S, increased the diameter of S, thus producing an additional tension in the spring.

As soon as M is drawn a little further outward (to the left) than is shown at II, then the point of maximum diameter of K will be on the left-hand side of the spring. Since the spring is under tension it will tend to decrease its diameter. This forces S to slide along K to the right—toward a point of smaller diameter. The spring in sliding along K, strikes the cross-piece C, which is fastened to the blade, B, and it thereby carries B to the right and causes B to contact with the jaws, J, as shown at III. Thus, the switch is closed. In opening the switch, the operation is substantially the reverse of that just described.

28. Electric Lighting Switches May Be Further Classified As To Operating Method into (Table 21): (1) *Rotary-button switches.* (2) *Push-button switches.* (3) *Pull-switches.* (4) *Toggle-lever or tumbler switches.* (5) *Knife-handle switches.*

29. A Rotary-button Switch (Fig. 16) is defined as one the operation of which is effected by turning a button.

30. A Push-button Switch (Fig. 21) is defined as one the operation of which is effected by pushing a button. Some switches of this type have only one button while others have two (see Div. 2.)

Note.—Push-button Switches Are Manufactured In Both The Surface And Flush Types; and, as shown in Table 21, may have either revolving-blade or oscillating-blade mechanisms. However, rotary-button switches are usually made (with revolving-blade mechanism) in the surface type, and push-button switches in the flush type.

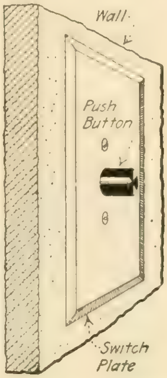


Fig. 21.—Flush switch of the push-button type.

31. A Pull-switch is one (Fig. 22) the operation of which is effected by pulling a chain or cord. Usually one pull on the chain closes the switch and the next pull opens it.

32. A Toggle-lever Or Tumbler Switch (Fig. 23) is one which is operated by moving a small lever which extends from the switch.

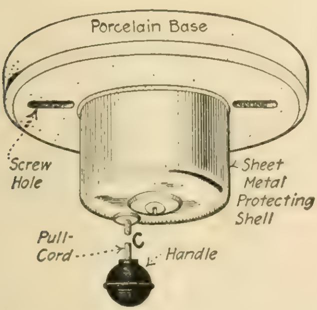


Fig. 22.—Ceiling-type pull-switch.

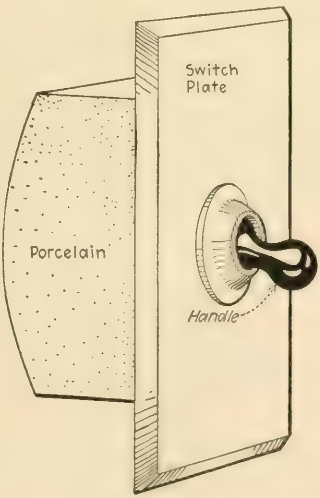


Fig. 23.—Flush toggle or tumbler switch and switch plate, with switch box removed.

33. A Knife-handle Switch (Fig. 18) is one which is operated directly by a handle which is attached, without

intervening mechanism, to the swinging end of the switch blade or blades. This operating method is principally employed for knife-blade switches.

34. Electric Lighting Switches May Be Further Classified As To Mounting Design into: (1) *Surface switches.* (2) *Flush switches.* (3) *Pendent switches.* (4) *Straight-through switches* (see Table 21).

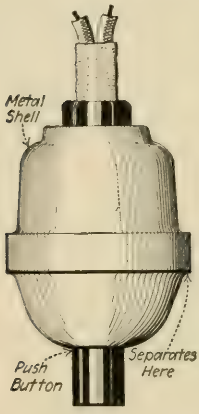


Fig. 24.—Pendent switch.

35. A Surface Switch (Figs. 16 and 22) is one which is designed primarily for mounting on an exposed surface and which is so made that none of it extends inward through the surface. See Table 21 for variations in the application and design.

36. A Flush Switch (Fig. 21) is one which is designed primarily for installation in, and so that its outer face will be practically flush with, the surface of a wall or partition (see Secs. 101 and 146).

Note.—The Terms "Surface" And "Flush" As Used In Switch Nomenclature are usually applied to switches of the "snap" type.

37. A Pendent Switch (Fig. 24) is one which is designed for installation on the end of a flexible cord which usually hangs suspended from some point above.

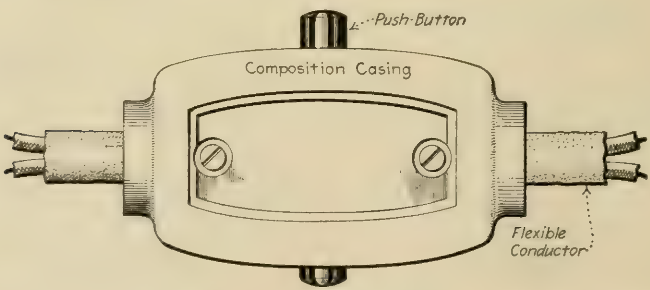


Fig. 25.—A straight-through switch. (*Beaver Machine & Tool Co., Newark, N. J.*)

38. A Straight-through Switch (Fig. 25) is one which is designed for mounting in a flexible conductor so that the conductor enters and leaves the switch in a practically-straight

line. It is sometimes called a *feed-through switch* or a *cord switch.*

Note.—The Underwriters' Laboratories Define A Pendent Switch as: "A switch designed to be installed at the end of or in the middle of a flexible cord." Such a definition will include switches of each of the types as defined in Secs. 37 and 38.

39. A Snap Switch is, strictly speaking, any switch which opens and closes with a "snap," regardless of how rapidly or slowly its operating button or handle is moved by the person who operates it. An automatic spring-actuated mechanism within the switch provides this action. All electric-lighting switches should, to conform to the National Electrical Code recommendation (Rule 24*b*) be quick-break or snap switches. However, certain switch manufacturers use the term "snap switch" to designate only a rotary-button-operated surface switches as for example that of Fig. 16.

40. Electric Lighting Switches May Be Further Classified As To Circuit Connections (see Table 21) into: (1) *One-point switches.* (2) *Two-point switches.* (3) *Three-point switches.* (4)*Four-point switches.* (5) *N-point switches*, the letter "*N*" being used as a symbol to indicate any number of "points." (5) *Single-pole or one-pole switches.* (6) *Double-pole or two-pole switches.* (7) *Triple-pole or three-pole switches.* (8) *Four-pole switches.* (9) *N-pole* switches, the letter "*N*" being used as a symbol to indicate any number of poles. (10) *Three-way switches.* (11) *Four-way switches.* (12) *Single-throw switches.* (13) *Double-throw switches.* (14) *Electrolier switches.* (15) *Series-parallel or heater switches.* All of the types which have just been listed are defined and illustrated in subsequent sections. There may also be other circuit-connections and sub-classifications.

41. A "Switch-position," Or The "Position" Of A Switch May Be Defined As any stationary position of a switch-blade which will provide a certain definite circuit-connection within the switch. That is, *a two-position switch* is a switch wherein the blade or blades have two, or more, stationary positions *which provide only two different circuit-connections.* A three-position switch provides only three different circuit connec-

tions. A single-throw knife-switch has two positions, "open" and "closed." A double-throw knife-switch may be connected to provide either two or three positions, "closed right," "open" and "closed left." Snap-switches which have more than four positions are seldom manufactured (see Secs. 86, 93, 296, and 299).

42. Much Confusion Has Resulted From Erroneous Switch Terminology As Regards The Terms "Three-point," "Three-pole," and "Three-way." Any or all of these terms are frequently used in describing the same switch (see Figs. 13 and 14). Also, *four-point*, *four-pole*, and *four-way* are often used interchangeably in designating the same device. Some switch-manufacturers have called their three-way and four-way switches, three-point and four-point switches. This has increased the confusion. Each of these terms has a certain definite meaning, and should only be applied to a certain definite type of switch. Specific definitions of this switch terminology are given in the following sections.

43. The Definition Of A One-point, Or Single-point, Switch (Fig. 19-*I*) may be stated as: A switch which has a metallic lever so pivoted at one end, that when the lever is rotated about the pivot as a center, the other end which moves in a circular arc will make contact with a stationary metallic button, called a *contact button*. One conductor (*A*, Fig. 19-*I*) is connected to the pivoted-end of the lever, and another conductor, *B*, is connected to the contact button. Switches of this type are usually employed only in low-voltage signal work.

44. The Definition Of A Two-point, A Three-point, Or A Four-point Switch (Fig. 19-*II*, -*III*, -*IV*) may be given as: A switch which is identical with the one-point switch in operation, and in construction (Sec. 43), except that there are, respectively, two, three, and four contact buttons on a two-, a three-, and a four-point switch. Thus, with a four-point switch, an electric circuit (Fig. 26) may be closed through the battery, *P*, and any one of the four subsidiary circuits, *A*, *B*, *C*, or *D*, by placing the switch lever on the contact button, *a*, *b*, *c*, or *d*, and then closing the push-button, *M*.

NOTE.—A PUSH-BUTTON SHOULD BE INSTALLED IN ANY MULTI-CIRCUIT SIGNALLING SYSTEM WHICH EMPLOYS A THREE- OR A FOUR-

point Switch. The necessity for this is that should the metallic lever be rotated from contact button a to d (Fig. 26) the lever might, in being shifted, make contact with buttons b and c, thereby causing lamps B and C to light momentarily, before the lever could reach d.

45. A Single-pole Or One-pole Switch May Be Defined as: A switch whereby only one conductor, or lead, of an electric circuit can be opened or closed (see Figs. 19-*I*, 27-*I* and 30).

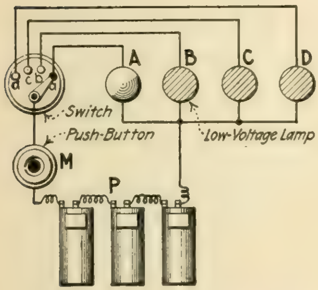


Fig. 26.—Showing signalling installation controlled by a four-point switch and push-button.

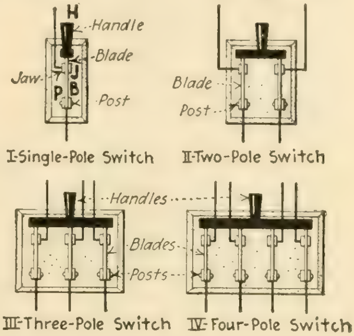


Fig. 27.—Single-pole, two-pole, three-pole and four-pole single-throw knife switches.

46. A Double-pole Or Two-pole Switch May Be Defined (Fig. 27-*II*) as: A switch whereby two conductors, or leads, of an electrical circuit, or two conductors, or leads, of two separate circuits, may simultaneously be opened or closed.

47. A Three-pole Switch May Be Defined as: A switch whereby each of three leads of a circuit, or of different circuits, can be simultaneously connected or disconnected (see Fig. 13-*XIX* and Fig. 27-*III*).

48. A Four-pole Switch May Be Defined as: One whereby each of four legs of a circuit, or of different circuits, can be simultaneously connected or disconnected (see Fig. 27-*IV*).

Note.—An N-pole Switch May Be Defined as: A switch whereby each of N (any number) leads of a circuit, or of different circuits, can simultaneously be connected or disconnected. From a consideration of Fig. 27, it will be noted that if four single-pole knife switches be mounted parallel to each other on a flat insulating base and the four handles connected together by a strip of rigid insulating material, a four-pole switch (Fig. 27-*IV*) will result. Switches having more than four-poles are seldom used.

49. The Definition Of A Three-way Switch may be stated as: A switch (Fig. 28) which has four binding posts, two adjacent posts (*A* and *B*) being permanently connected by a shunt, *S*, so located that the contact bar, *C*, will, when moved around a central pivot, effect an electric connection between diagonally-opposite binding posts (see Div. 5). A three-way switch is sometimes called a *combination switch*. It should *not* be called a three-point switch or a three-pole switch.

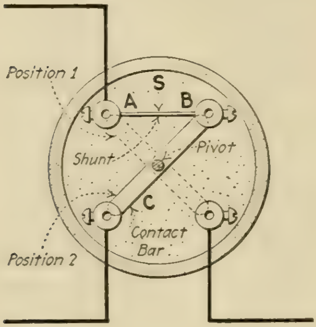


Fig. 28.—Diagram of a three-way switch.

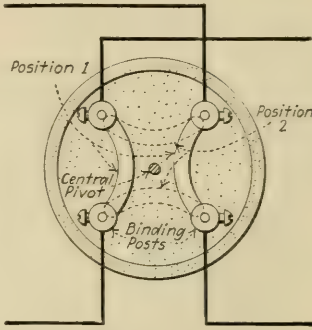


Fig. 29.—Diagram of a four-way switch.

50. A Four-way Switch May Be Defined as: A switch (Fig. 29) which has four binding posts and two contact bars, which are insulated from each other, so arranged that by moving the contact bars around a central pivot, electrical connection can be effected between any two adjacent posts and simultaneously connection is made between the other two posts. This type of switch is sometimes called a *commutating switch*. It is also *incorrectly* called a four-point switch or four-pole switch.

Note.—This Definition Of A Four-way Switch Is Based On The Construction Of These Switches As They Are Usually Manufactured. A double-pole double-throw switch (Sec. 229) may, however, be so wired that the connections which it effects are equivalent to those made by a four-way switch.

51. A Single-throw Switch May Be Defined as: A switch (Figs. 27 and 30) the blades or contact bars of which, when operated, contact with only one set of contacts. As indicated in Fig. 27, single throw switches may be of either the single-pole or multi-pole type but they need not necessarily have

knife-blade mechanisms, though the use of the term is usually confined to mechanisms of this type.

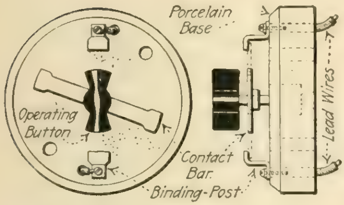


FIG. 30.—Principle of operation of single-pole, single-throw snap switch.

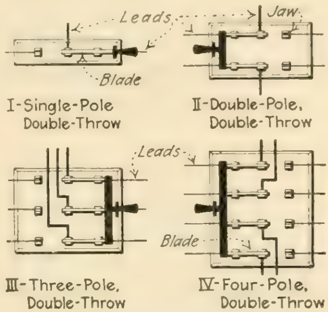


FIG. 31.—Illustrating various types of double-throw knife switches.

52. A Double-throw Switch May Be Defined as: A switch (usually a knife switch), Fig. 31, wherein the blades, or contact bars, may be operated to make contact with either of two sets of binding posts, or contacts. As shown by Fig. 31, double-throw switches may be of either the single- or multipole type. Double-pole, double-throw switches are also manufactured in the *snap* type.

53. An Electrolier Switch May Be Defined as: A switch which has its binding posts and contact bars so arranged that two or more energy-utilizing-device circuits may be controlled by placing the contact bars in different positions. A diagram of a simple electrolier switch-circuit is shown in Fig. 32 (see also Div. 7).

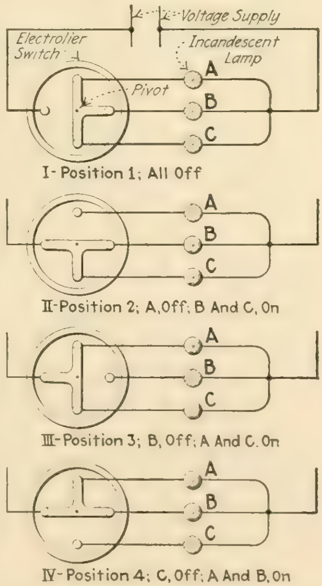


FIG. 32.—Illustrative diagram of an electrolier switch and its circuits.

54. A Series-parallel Or Heater Switch May Be Defined as: A switch which has its binding posts and contact bars so arranged and connected that two or more energy-consuming-

device circuits may, by successive operations of the contact bars, be connected into the circuit either in parallel or in series. Such an arrangement, employing a double-throw, double-pole knife switch is shown in Fig. 33. This switch is also furnished by manufacturers in the snap type (see Div. 7).

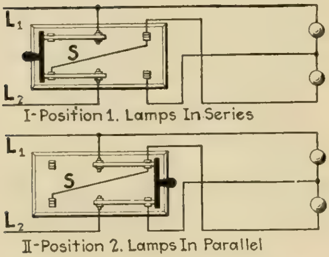


FIG. 33.—Double-throw, double-pole knife switch having two binding-posts connected by shunt, *S*, to form a series-parallel switch.

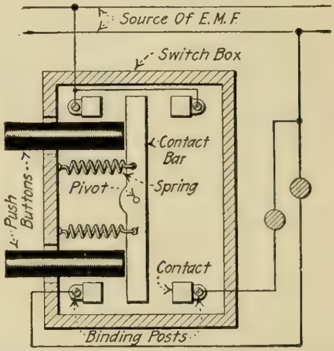


FIG. 34.—Diagram of a two-circuit momentary-contact switch.

55. A Momentary-contact Switch May Be Defined (Fig. 34) as: A switch which operates to close one or more circuits only while force is exerted on its contact bar. Switches of this class are usually made in the push-button type (see Divs. 2 and 8).

56. A Master Switch is any switch which is so connected that it may be operated to light or to extinguish simultaneously all of the lamps, or only specially designated ones, in an installation, irrespective of the positions or operation of the switches which regularly control the individual lamps or circuits (see Div. 6). This definition applies specifically to lighting circuits of all buildings except theatres. See note below.

NOTE.—THE TERM "MASTER SWITCH" AS USED IN THEATRE PARLANCE has a meaning which is somewhat different from that defined above (see Sec. 416).

57. A Service Switch (*O*, Fig. 2) is a switch through which the service wires (Fig. 6) connect to a building-interior wiring

system. It is (except as outlined in Sec. 134) so connected that it will, when open, disconnect from the source of supply all devices and wiring which are within the building.

58. A Barrier is defined as a non-combustible, non-absorptive insulating block which is placed between current-carrying parts of opposite polarity to prevent arcing or "flash-overs" between the parts.

EXAMPLES.—Barriers (Sec. 129) are often placed on knife switches between the hinge jaws, the break jaws and the metallic supporting blocks. They may be of sheet asbestos, of slate, or of similar materials. Barriers, usually of concrete, are arranged between busbars in station switching structures. Barriers of porcelain, cast integral with the base, are frequently provided on porcelain fusible-cutout-and-switch bases.

59. A Sub-base (Fig. 159) is defined as a non-combustible, non-absorptive insulating block which is installed under flush snap switches or other electrical devices which are designed for surface mounting—and which is so constructed as to raise the switch or device off of the surface and to prevent the conductors which enter the switch or device from contacting with the supporting surface.

NOTE.—SUB-BASES ARE USUALLY MADE OF PORCELAIN (see. Div. 3) but wooden sub-bases may be used under certain conditions. Also sub-bases are sometimes made of marble, slate, glass or other materials which will satisfy the requirements which are specified above.

60. A Cutout, as the term is applied in electrical parlance, is defined as device which is so constructed that it will automatically open any circuit, in which it is connected in series, when the current in that circuit exceeds the value at which the cutout is designed or adjusted to operate. See Fig. 168 for an illustration of a fuse cutout.

EXAMPLES.—An automatic overload circuit breaker, or a fuse mounted in a cutout base are examples of cutouts. The CODE considers that a cutout base and a fuse which the base carries constitute a cutout. Commercially, the base and receptacle which are designed to carry the fuse are called a cutout.

EXPLANATION.—When the current through a fuse exceeds, for a relatively-short time, the ampere current rating value which is printed or stamped on the fuse, then the fuse wire will melt and thereby open the circuit in which it is connected in series. When the current through an overload circuit-breaker exceeds the ampere current value for which the

breaker is set, then the breaker will trip and open the circuit in which it is connected in series. Thus an overload circuit-breaker opens instantaneously when the current through it exceeds the value for which it is set. A time-limit circuit-breaker will not open until after the current for which it is set has flowed through it for a certain predetermined time for which the breaker is also set.

61. A Panel Board (Fig. 5) is a device upon which are mounted fuse receptacles and switches—or cutouts and switches, *S*,—for the control and protection of the branch circuits, *B*, which are fed from the main, *M*, supplying the energy to that panel board. A panel board usually has two or more branch circuits leading from it. These branch circuits are fed from busbars, *E*, which are connected to the main, *M*. This device is ordinarily enclosed in a protective box, which is called a *panel-box* or *cabinet*. The complete apparatus—the cabinet and the panel board—is sometimes termed a *distribution center* (Sec. 9).

QUESTIONS ON DIVISION 1

1. Define the following terms: *Electric circuit; closed circuit; open circuit; external circuit; internal circuit; short circuit.*

2. Draw a sketch to illustrate each of the terms which you have defined in Question 1.

3. Define a *feeder.*

4. In circuit nomenclature, what may be considered as the *source of energy?*

5. What is a *sub-feeder? Main? Sub-main? Branch? Tap?*

6. Draw a sketch illustrating each of the terms mentioned in Question 5.

7. What is a *distribution center?*

8. What is a *service?* Make a sketch to illustrate.

9. Define a *lead.* What other terms may be used interchangeably with *lead?* Give examples.

10. What is a *phase-wire?* What term is frequently erroneously used for *phase-wire?*

11. What is a *traveler?* Draw a sketch to illustrate.

12. What two devices largely govern circuit terminology?

13. Show by sketches: How a *sub-feeder* may be changed to a *main;* how a *main* may be changed to a *branch;* how a *branch* may be changed to a *tap.*

14. What terms are frequently incorrectly applied to the same switches?

15. Define a *switch.*

16. What is a *one-point switch? Two-point switch? Three-point switch? Four-point switch.* Draw a sketch of each.

17. For what applications are *point-switches* generally used?

18. What other type of switch should be employed in connection with a three- or a four-point switch? Why?

19. Define a *single-pole switch; double-pole switch; three-pole switch.*

20. Make a sketch of and define a *three-way switch; four-way switch.*

21. What other type of switch may be used to provide four-way-switch control?

22. What is a *double-throw switch?*

23. Define: *Electrolier switch; series-parallel switch; momentary-contact switch.*

24. Draw a diagrammatic sketch showing the operation of each of the switches mentioned in Questions 22 and 23.

25. What is a *master switch?*

DIVISION 2

LIGHTING-SWITCH CONSTRUCTION

62. Knife Switches, Or Lever Switches, Are Simple In Construction. A thorough and complete understanding of the operation of, and of the available circuits through a knife switch may be readily obtained by a cursory examination of it. The purpose of the following sections relating to knife switches, is to present various features of construction that are at present embodied in knife switches by the principal manufacturers.

63. The Names Of Knife-switch Parts are given in Fig. 35. Every knife switch has one or more metallic blades, *B*, each blade being so hinged at one end to a metallic post, *P*,—hinge-

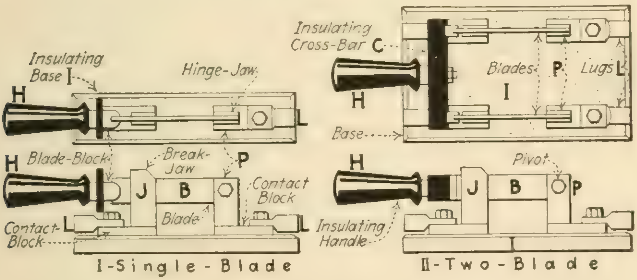


FIG. 35.—Illustrating nomenclature of knife-switch parts.

jaw—that by operating *B*, which moves in a plane perpendicular to the base, about *P* as a pivot, the opposite end of each of the blades will fit into and make contact with a metallic jaw, *J*—break-jaw. This opposite end of the blades is equipped with a handle, *H*, which is made of insulating material. In those switches of the multi-blade (multi-polar) type, a cross-bar, *C*, which is made of an insulating material, rigidly connects the blades together. The hinge-jaws, *P*, and the break-jaws, *J*, are usually equipped with some sort of binding-post or lug, *L*. The binding-posts, which are mounted on an insulating

base, *I*, are merely for convenience in connecting and disconnecting the current-carrying wires.

64. The Materials Used In Knife-switch Construction May Be Classified as: (1) *Conductors* or *current-carrying parts.* All current-carrying parts of knife switches are ordinarily made of copper. (2) *Insulators* or *non-current-carrying parts.* The binding-posts, blades, jaws and contact-blocks (Fig. 35) comprise the current-carrying parts. The base, handle, and cross-bar (Fig. 35) comprise the non-current-carrying parts. Various forms in which each of these parts are made and the methods of fastening one part to another are described in the following sections.

65. Knife-switch Blades (*B*, Fig. 35) are usually stamped or machined from solid hard-drawn copper of about 98 per cent. conductivity (see note below), and then, in the best construction, ground flat. *The maximum current-carrying capacity allowed for the blades of knife switches is about* 1,000 *amp. per sq. in. of cross-sectional area.* That is, if a switch is to carry a current of 600 amp., the cross-sectional area of the blade must be at least: $600 \div 1{,}000 = 0.6$ *sq. in.* However, in the small-capacity knife switches, this minimum-allowable cross-sectional area (0.001 sq. in. per amp.) of the blades is, to secure sufficient stiffness and mechanical strength, usually exceeded —frequently being as large as 0.025 sq. in. per rated ampere or 400 amp. per sq. in. Even in the large-capacity switches, manufacturers usually, to take care of accidental overload, make the cross-sectional blade-area somewhat greater than the minimum allowed.

Note.—The Maximum Temperature Rise Of The Switch Parts Over The Temperature Of The Surrounding Air Should Really Determine The Minimum Amount Of Material Which Should Be Incorporated In Any Given Switch. The "maximum temperature rise" is that attained while the switch is carrying continuously its rated full-load current. Rules such as those given above serve as guides, but a temperature-rise test should be the final criterion. In its Standard For Snap Switches the *Underwriters' Laboratories* specifies that, "all snap switches, must have ample metal for stiffness and to prevent rise in temperature of any part over 54° F. (30° C.) at full load. The American Institute Of Electrical Engineers Standardization Rules specifies this same maximum temperature rise for all switches.

NOTE.—SOLID HARD-DRAWN COPPER HAS A CONDUCTIVITY OF 98 PER CENT. if 1 g. of the material, when drawn into a wire of uniform circular-cross-section and 1 m. in length, has a resistance of 0.15,538 ohms at a temperature of 20° C. (68° F.).

66. Knife-switch Jaws are made of copper. For the successful operation of a knife switch, it is essential that the jaws make firm contact with the blades. This is accomplished by making the jaws of resilient "springy" hard drawn copper. Several different forms of jaws (Fig. 36) are used. The principal forms are described below. The break-jaws of

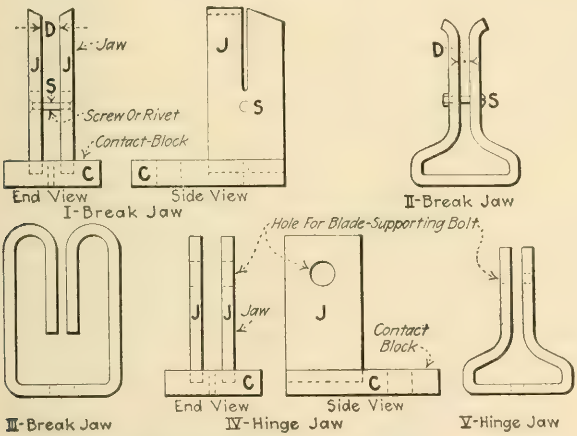


FIG. 36.—Showing various forms of knife-switch jaws.

Fig. 36-*I* are made by sweating and pinning the jaws, *J*, to the contact-block, *C*. Those shown at *II* and *III* are made of hard sheet copper, which is pressed into the forms shown. The break-jaws are frequently provided with a screw, rivet, or bolt (*S*, Fig. 36-*I* and *II*) to form a *stop* to prevent the switch blade from being pushed too far down into the jaws; it may also be used to adjust the distance *D*. The two different types of hinge-jaws, *IV* and *V*, are constructed in a manner similar to that of the break-jaws of *I* and *II*, respectively.

67. Knife-switch-blade Hinges (Fig. 37) usually consist of a bolt inserted in the hinge-jaws, thus forming a pivot about which the blades may rotate. In switches of cheaper grades,

this pivot is sometimes merely a rivet with its heads spun over. A construction which provides a ready means of adjusting the hinge-jaw is shown in Fig. 37. The stud, S, is threaded on both ends. Each end is then provided with two nuts—a

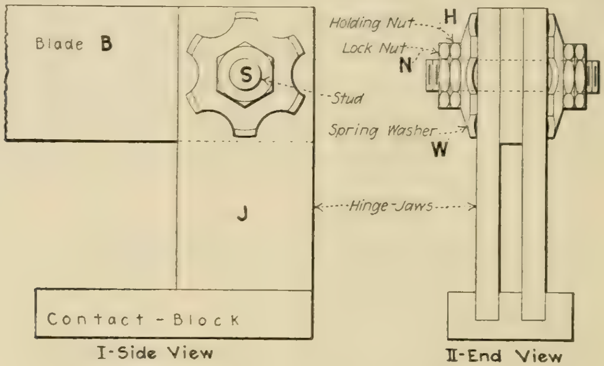


FIG. 37.—Blade hinge for knife-switch hinge-jaw.

holding-nut, H, and a lock-nut, N—and a spring-washer, W. This spring washer is preferably made of spring brass or phospor bronze but it may be of steel where the switch will not be exposed to moisture. When the assembly is made as shown

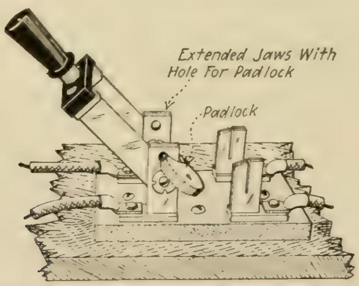


FIG. 38.—Knife switch provided with extended hinge-jaws so that the switch blades may be locked in the open position.

in the illustration, the nuts may be tightened down on the spring-washers, thus insuring firm contact between the blade, B, and the jaws, J.

NOTE.—THE SWITCH BLADES MAY BE LOCKED IN THE OPEN POSITION by using a pad-lock in connection with a hinge-jaw of the type shown

in Fig. 38. Such a device is desirable where a workman may wish to lock "dead" a certain part of the line upon which he may be working.

NOTE.—STOPS WHICH LIMIT THE ARC OF SWITCH-BLADE THROW TO 90 DEG. may be provided on the hinge-jaws as shown in Fig. 39. This permits the mounting of switches and other apparatus in a smaller space than that which would be required if it were necessary to provide sufficient clearance to throw the blades all the way over through an angle of 180 deg.

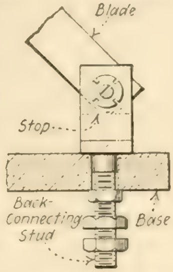


FIG. 39.—Stop-mechanism to limit the arc of switch-throw.

68. Knife-switch Jaws Must Be So Secured To The Base That They Cannot Turn On The Base. This is done by means of dowel-pins or screws as described in Sec. 126, or in some instances, where jaws of the type shown in Fig. 36-*II*, *III* and *V* are used, a square hole is countersunk into the base (Fig. 40), and the jaw, which is fitted into the square hole, is secured to the base by a single screw.

69. The Wires Are Connected To Knife Switches By Means Of Binding-posts (Fig. 40). The point of connection is also sometimes called the *switch terminal.* In *front-connected knife switches* (Fig. 41)—wherein the wires are connected to the switch on the same side of the base as that upon which the

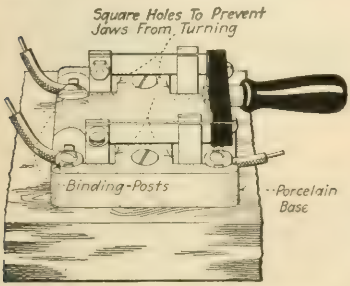


FIG. 40.—Showing the method of preventing switch jaws from being turned on the base by fitting them into countersunk square holes.

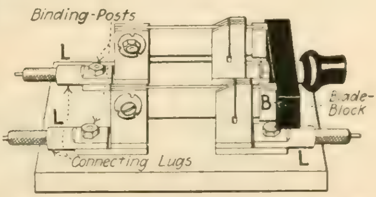


FIG. 41.—Showing connecting-lugs on a front-connected switch.

switch is mounted—the binding-posts frequently consist of one of the contact-block holding-bolts. However, in Fig. 40, the terminal which carries the binding-post is separate from the jaw, and is secured thereto by the jaw holding-screw.

In *back-connected knife switches* (Fig. 42)—wherein the wires are connected to the switch on the side of the base opposite to that upon which the switch is mounted—the binding-posts take the form of a stud, *S*. One end of this stud is soldered into the contact-block. The wire, if of a size No. 8 gage, or smaller, is secured to the other end of the stud by nuts.

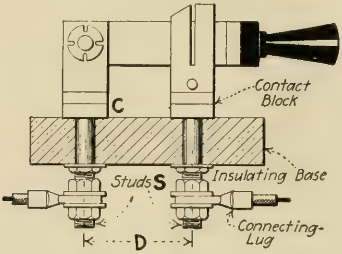


Fig. 42.—Showing connecting-lugs on a back-connected switch. (Switches of this type are permitted only on switchboards.)

Note.—Connecting-lugs Must Be Used In Connecting Wires Of A Size Larger Than No. 8, B. & S. Gage, To Switches (Code Rule 16 *c*.) The lug is secured to the binding-post (Fig. 41), or to the stud (Fig. 42) by a nut or nuts, and the wire is soldered into the lug. Various types of connecting-lugs or terminals are shown in Fig. 43.

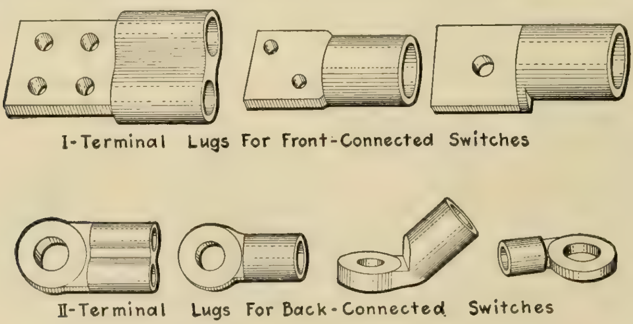


Fig. 43.—Showing various types of knife-switch connecting-lugs.

70. The Materials Of Which Knife-switch Bases Are Constructed are, because of Underwriters' (Sec. 121) and service requirements, practically limited to the following: (1) *Marble.* (2) *Slate.* (3) *Porcelain.* (4) *Composition* such as hard fiber, bakelite, transite or "moulded mica." The large-capacity switches are generally provided with slate or

marble bases, while the bases for those of small capacity are usually of porcelain or a patented composition. Slate is, for voltage under 1,000, preferable because it is the stronger.

71. The Blades Of Multi-pole Knife Switches Are Mechanically Connected Together By A Bar Of Insulating Material Called A Cross-bar (*C*, Fig. 35-*II*). This cross-bar is usually made of hardwood, composition, or fibre, which is machined to shape and, often, polished. In some of the small-capacity switches, the cross-bar is made of porcelain. The cross-bar is in the better switches secured to the blade by means of a blade-block, (*B*, Fig. 41) which is fitted into a groove in the cross-bar and held therein with screws, bolts or rivets. In some low-priced switches, the end of the blade is bent over, and screwed to the cross-bar as shown in Fig. 40.

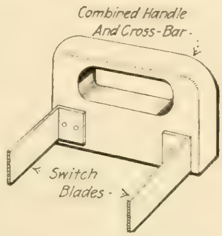


FIG. 44.—Fibre spade-handle often used on 30-amp., double-pole switches.

72. Knife-switch Handles (*H*, Fig. 35) are usually made of hard-wood. They are shaped in a turning-lathe and then heavily enameled or varnished. However, some switch handles are made of porcelain or composition. The handle is, in single-pole switches (Fig. 35-*I*), secured to the blade by a blade-block and a screw or bolt. The blade-block is soldered, sweated, or pinned to the blade. The screw or bolt, which passes through the handle longitudinally, is then screwed into

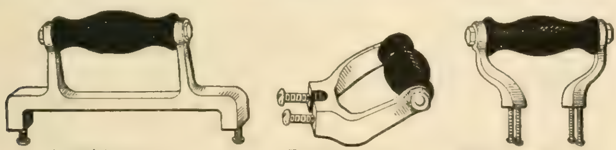


FIG. 45.—Types of spade-handles used on large-capacity multi-pole switches.

the blade-block. In multi-pole switches (Fig. 35-*II*), the handle is fastened to the cross-bar by a bolt. In the small 30-amp. switches which are used on distributing panels the composition handles (Fig. 44) form both a cross-bar and a handle. Spade-handles (Fig. 45) are often used on large-capacity switches because of the more convenient and effective

grip which they afford. "Spool" handles (Fig. 46) are also frequently used for 30-amp. switches.

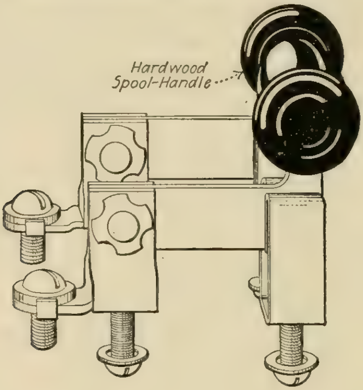


FIG. 46.—A 30-amp. panel-board switch having a spool-handle.

73. Knife Switches May Be Classified According To The Form Of The Switch as shown in Table 74. That is, knife-switches are made single-, double-, three-, four-, five-, and six-pole; single- or double-throw; fused or unfused. If any of the above combinations are unfused, they may be provided with either front or back connections (Sec. 69). If they are fused, the fuse terminals may be located on either the front or on the back of the base, and may be of such a type as to hold either link or cartridge fuses. If front-fused, the switch may be either front- or back-connected. However, if the switch is back-fused, it is usually back-connected.

74. Table Showing Knife-switch Classification According To The Form Of The Switch.

Pole	Throw	Fuses		Connected
Single. Double. Three. Four. Five Six.	Single. Double.	No fuse		Front. Back.
		Front-fused.	Open link. Cartridge.	Front. Back.
		Back-fused.	Open link. Cartridge.	Back.

75. Knife-switch Troubles usually first reveal themselves by the switch becoming heated. These troubles are ordinarily caused by: (1) *Loose terminals.* (2) *Improper contact between the blade and jaws.* The remedy for the first-mentioned trouble is, obviously, to tighten the loose connection. A method of locating and correcting the second trouble is described in the following section.

NOTE.—THE MAXIMUM-ALLOWABLE CURRENT DENSITY AT THE BLADE-AND-JAW CONTACT OF A KNIFE SWITCH is about 75 amp. per sq. in. That is, the total contact-area between the blade and the jaw of a 100-amp. switch should at least be: $100 \div 75 = 1.33$ *sq. in.*, or: $1.33 \div 2 = 0.67$ *sq. in.* on each side of the blade. If the jaws become deformed so that only two edges of the jaws contact with the blade, a large overload of the small contact area will result and the switch will thereby become heated.

76. A Test For Proper Blade-and-jaw Contact may be made by trying to insert a piece of very thin mica or paper between the jaw and the blade at the corners and sides. The thickness of this "feeler" should not exceed one or two mils (0.001 to 0.002 in.). If the "feeler" can be inserted between the blade and jaw at any point, it is evident that the contact is bad. Another means of locating an improper blade-and-jaw contact, which may sometimes be used, is: Hold the switch between the eye and a strong light. Move the switch about so that the contact may be examined from every possible angle. If light can be seen between the blade and jaw, the contact is bad. If improper contact is found to exist, it may be corrected by the method which is outlined in the following section.

77. A Poor Blade-and-jaw-contact May Be Corrected by the following procedure: If the bad contact is at the hinge-jaw, it may usually be remedied by tightening the nut or the rivet of the hinge-pivot. If it is at the break-jaw, the jaws may first be bent into a more-nearly correct position either by hand or by driving a block of wood against the jaw with a hammer. Then apply a mixture of vaseline and fine pumice stone (FF) to the contact-surfaces of the blade and jaw, and work the blade in and out several times. The bending of the jaws increases the friction between the blade and jaws, and the working-in-and-out process grinds off any "high places."

This grinding not only improves the "fit," but removes any lacquer or other foreign material, which is sometimes the cause of bad contact. The switch should, of course, be entirely isolated from any source of voltage during the above operations.

78. Table Showing Approximate Selling Prices Of 250-volt Front-connected Knife Switches Mounted On Slate Base And Provided With Cartridge Fuse Terminals. (The cost of the switches will vary somewhat, depending upon the locality and the quantity purchased. The prices of similar switches, which are back-connected, which have open link fuse terminals or no fuse terminals will not vary greatly from the prices shown. Switches for 500 volts cost relatively little more than 250-volt switches.)

Current rating, Amp.	Form					
	Single-pole		Double-pole		Three-pole	
	Single-throw	Double-throw	Single-throw	Double-throw	Single-throw	Double-throw
30	$ 2.15	$ 3.25	$ 3.75	$5.75	$ 5.25	$ 8.30
60	2.65	3.85	4.60	7.10	6.65	10.65
100	4.60	7.35	8.55	14.00	12.55	20.85
200	6.50	10.85	12.70	20.90	18.75	31.00
400	10.75	17.35	21.10	35.00	31.30	51.75
600	16.95	27.20	33.05	54.70	49.10	81.25
800	23.10	36.85	44.50	71.15	66.20	107.10
1,000	29.50	48.90	58.15	94.15	86.55	141.80
1,200	33.40	54.45	65.85	105.10	98.10	158.00

79. The Mechanisms Of Snap Switches May Be Considered As Consisting Of Three Elements: (1) *Conductors,* or *current-carrying parts.* (2) *Insulators,* or *non-current-carrying parts.* (3) *Operating mechanism.* While the operating mechanism is always made of conductor-material (metal), it does not normally carry current. Each of these elements is described in the following sections. Various snap-switch elements are shown in Figs. 47, 48, 49, and 50.

80. The Conductors, Or Current-carrying Parts, Of Snap Switches (Sec. 39) are the: (1) *Binding-posts,* (*P*, Figs. 51 and 52). (2) *Stationary contractors,* (*C*, Figs. 51 and 52). (3) *Movable contactor,* or *blade.* (*B*, Fig. 52). Various forms, and

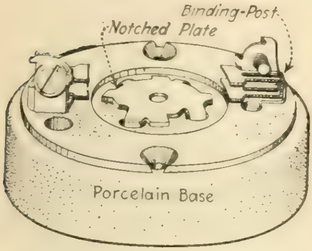


FIG. 47.—Showing arrangement of binding-posts, and method of fastening notched plate to porcelain base, for a single-pole, surface snap switch.

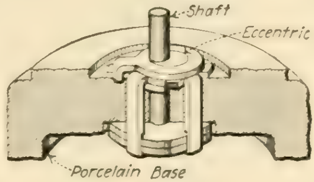


FIG. 48.—Section of porcelain base showing eccentric on shaft.

the materials of manufacture, which are employed in the construction of snap-switch current-carrying parts are discussed in the following sections.

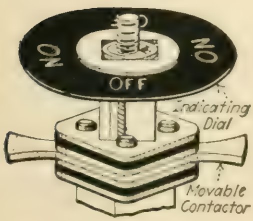


FIG. 49.— Movable-contactoı and indicating dial for single-pole, revolving-blade snap switch.

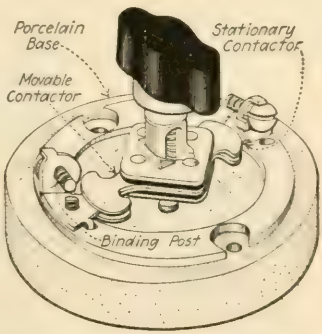


FIG. 50.—Single-pole, revolving-blade, surface snap switch with cover removed.

81. The Binding-posts—also called *terminal plates*—(*P*, Figs. 51 and 52) are the devices which hold the wires to the switch. The binding-posts (*P*, Fig. 51) are in electrical contact with the stationary contactor, *C*. Thus, when the movable contactor (*B*, Fig. 52) makes contact with the stationary contactors, *C*, a current-path through the switch is

established. The binding-posts are usually made of brass. They are made in innumerable different forms and shapes.

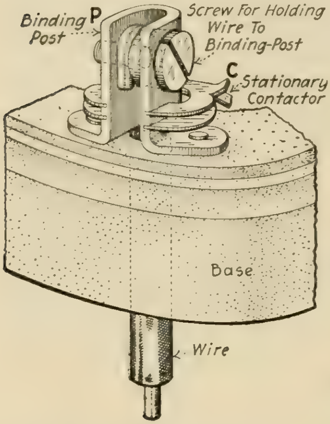


FIG. 51.

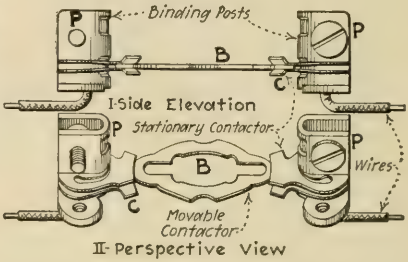


FIG. 52.

FIG. 51.—Showing one type of snap-switch binding-post with wire attached. (*Hart Mfg. Co.*) In wiring this binding-post, it is unnecessary to remove the binding screw or to loop the wire. The wire, after being skinned, is simply inserted in the post and then bent forward around the screw. It is then cut off to proper length. With a screw driver, the loose end is pressed under the head of the screw and the screw tightened.

FIG. 52.—Nomenclature of snap-switch current-carrying parts. (Movable contactor consists of a flat plate, and stationary contactors are of the jaw type.)

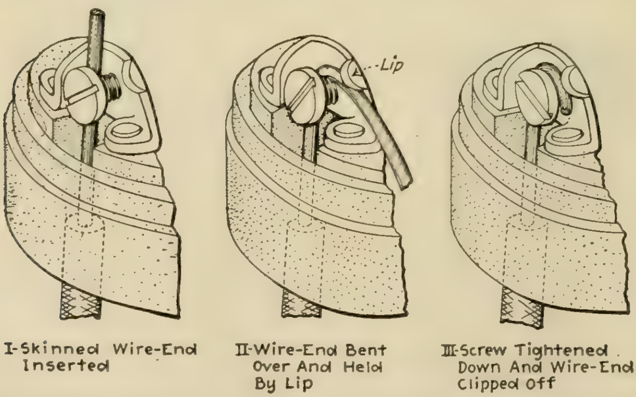


FIG. 53.—Method of "making up" connection in surface switch binding-post. (*Arrow Electric Co.*)

For examples of various forms of binding-posts, see Figs. 52, 53, 55 and 63.

82. The Principal Types Of Contactor-mechanisms are: (1) *The movable-plate-and-stationary-jaw contactor*, (Fig. 52),

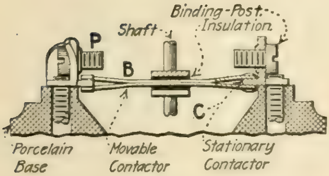


FIG. 54.—Illustrating contactor mechanism wherein the movable contactor, *B*, is of the jaw type and the stationary contactor, *C*, is of the plate type.

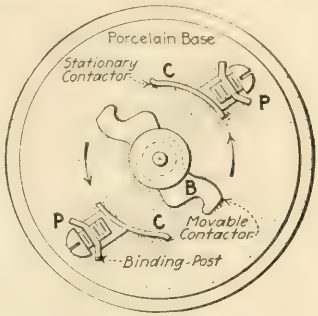


FIG. 55.—Illustrating end-contact type of contactors.

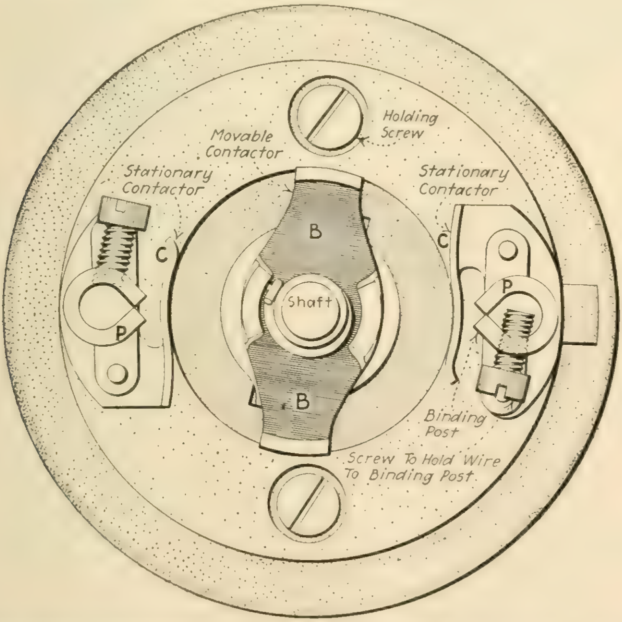


FIG. 56.—Single-pole, rotating-button snap switch having end-contactor mechanism. (Switch open, button and cover removed.)

wherein the movable contactor, *B* consists of a flat plate, the ends of which fit between the jaws of the stationary contactors,

C. (2) *The movable-jaw-and-stationary-plate contactor*, (Fig. 54), wherein the movable contactor, *B*, consists of jaws,

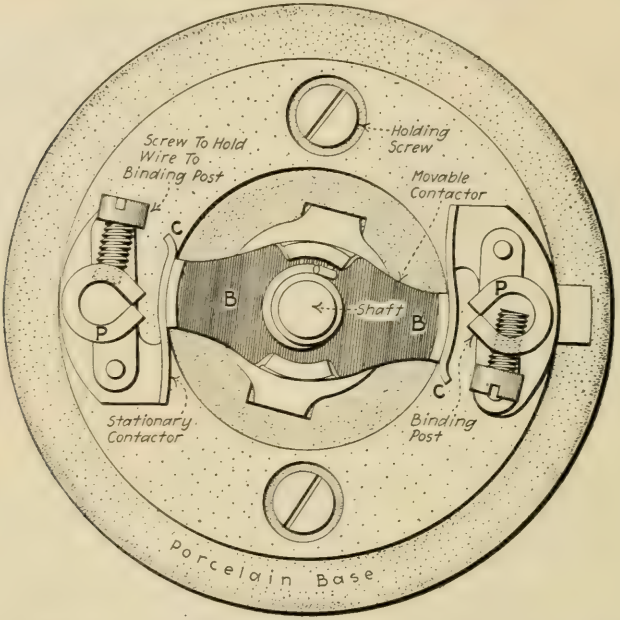


FIG. 57.—Single-pole, rotating-button, snap switch having end-contactor mechanism. (Switch closed, button and cover removed.)

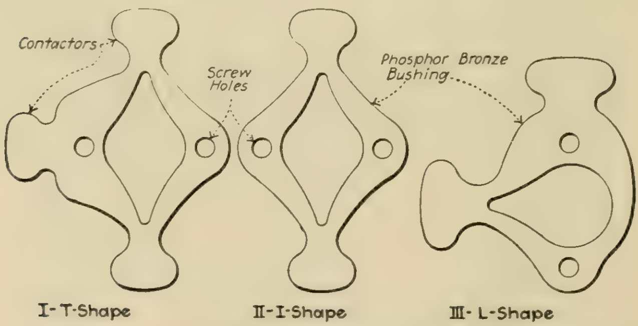


FIG. 58.—Illustrating different shapes of rotating-blade snap-switch movable contactors.

between which the flat-plate stationary contactors, *C*, fit. (3) *The end-contactor*, (Figs. 55, 56, and 57), wherein the ends of the movable contactor, (*B*, Fig. 55), rub against the station-

ary contactor, *C*. Those parts of a contactor-mechanism which must "spring" or "give" (*C*, Figs. 52 and 55; *B*, Fig. 54) are, usually, made of phosphor-bronze. Those parts which are not required to be resilient (*B*, Figs. 52 and 55; *C*, Fig. 54) are, usually, made of brass. Revolving-blade movable contactors of various shapes are shown in Fig. 58.

83. Snap Switches Are So Made, With Non-current Carrying Parts Of Insulating Material That There Are No Exposed Live Parts which might incur a life or fire hazard. These non-current-carrying parts consist of: (1) *A porcelain or molded-composition base* (Figs. 63 and 96-*I*), upon which the

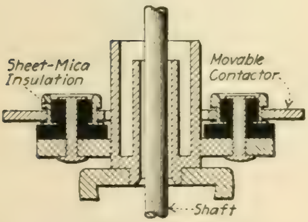


FIG. 59.—Method of insulating the movable contactor from the operating mechanism. (*Hart Mfg. Co.*)

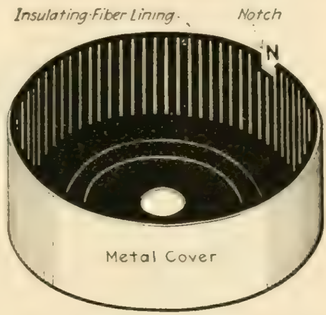


FIG. 60.—Metal cover lined with insulating material. (Notch *N*, fits on a lug carried by the base to prevent cover from turning.)

binding-posts and the operating mechanism are mounted. (2) *The insulating material which prevents the movable contactor from making electrical connection with the operating mechanism* (Figs. 59 and 77). This latter insulating material usually consists of sheet mica or fibre.

NOTE.—NOT ALL OF THE NON-CURRENT CARRYING PARTS OF A SNAP SWITCH ARE MADE OF INSULATING MATERIAL. Although the operating mechanism, and frequently the switch cover, are of conductor-material, normally they do not carry current, since they are, as explained above, insulated from the current-carrying parts.

NOTE.—A SNAP-SWITCH BASE ALSO SUPPORTS THE SWITCH OPERATING MECHANISM (Figs. 62 and 65). For surface and flush switches, (Figs. 63 and 67) the base is usually made of porcelain. Other forms of switches, such as the feed-through switch of Fig. 96 and the canopy switch of Fig. 100 have bases made of a patented insulating composition. The

switch mechanism for flush switches is completely enclosed on five sides, (Fig. 69) by a porcelain casing or container.

84. Metal Covers On Rotating-button Snap Switches Are Lined With A Fibre Insulating-material as shown in Fig. 60. Such an insulating lining is intended to prevent accidental short-circuiting of the binding-posts while removing or putting on the switch cover.

Note.—The Button, Or Handle Of A Snap switch (Figs. 16 and 68) is also of an insulating material: Usually molded-composition or porcelain. Normally the shaft, (S, Fig. 61) is not in contact with a source of voltage, but the button is made of insulating material merely as an additional precaution against the exposure of live parts to accidental contact.

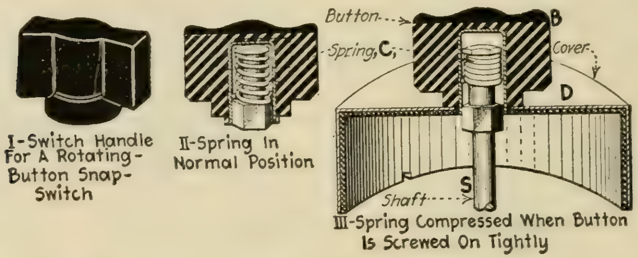


Fig. 61.—Showing one method of holding cover snugly to the base. (*Hart Mfg. Co.*)

Note.—Various Devices Are Employed To Hold The Cover Of A Surface Snap Switch Snugly Against The Base, one of which is illustrated in Fig. 61-*II* and *III*, and another in Fig. 62. When the button (B, Fig. 61-*III*) is screwed on to the shaft, S, the spring, C, is compressed. The tension of C, acting downward against the button, holds the cover, D, tightly against the base. The spring washer, W, of Fig. 62 performs the same function.

85. An Almost Infinite Number Of Different Operating Mechanisms Are Employed In Snap-switch Construction. Only a few, of the various types of operating mechanisms for the different forms of switches, are described herein in the following sections. The complicated construction of the snap-switch mechanisms is necessary to insure the "snap" action which is explained in the following note.

Note.—The Basic Principle Underlying The Operation Of Practically All Snap Switches is as follows: During the operation of a handle, the tension in a spring is increased. When the operation of

the handle has proceeded to a certain predetermined point, the blade, or movable contactor, is released. Upon the release of the movable contactor, the tension in the spring acts to move the movable contactor quickly through a predetermined distance. Hence, this movement of the movable contactor opens or closes the switch with an almost instantaneous "snap" action. The above operation will be more readily understood by a consideration of the following sections, wherein the functioning of various snap-switch mechanisms are described.

86. The Rotating-button, Revolving-blade Snap Switches, which are shown in Figs. 62 and 63 are single-pole, two-position, single-deck (Sec. 107) switches. By the term *two-position* is meant that the movable contactor, *B* has two stationary positions each of which provides a different internal circuit-connection (see Sec. 41). These two positions are at right-angles to each other. When, in one of the positions, as shown in the illustration, *B* and *B* are in contact with the stationary contactors, *C* and *C*. Then the switch is said to be in the *on-position, on,* or *closed.* When the switch is operated and the movable contactor turns to the other position, *B* and *B* is not in contact with *C* and *C*, and the switch is then said to be in the *off-position, off,* or *open.* The operation of this switch mechanism may be understood from a consideration of the following explanation.

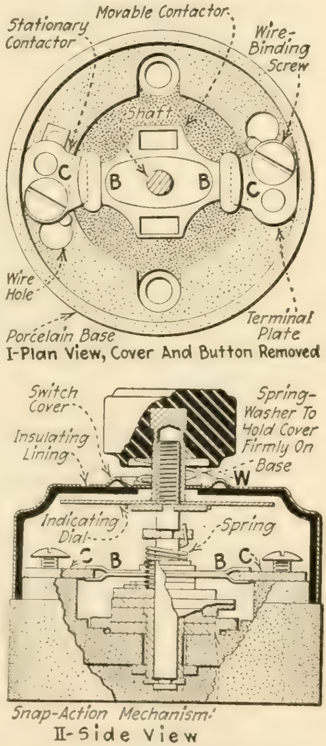


FIG. 62.—Illustrating construction of single-pole, surface, snap switch of the rotating-button type. (*Connecticut Electric Mfg. Co.*).

EXPLANATION.—The button-handle (*H*, Fig. 63) is rigidly fastened to the shaft, *S*, so that when *H* is rotated, *S* rotates with it. The movable contactor, *B*, and the plate, *D*, are rigidly fastened together. The shaft

S fits loosely in *D* so that *S* may be rotated without causing *B* and *D* to rotate. A flat circular "eccentric" metal-punching, (*R*, Fig. 64; shown also at *R*, Fig. 63) is rigidly fastened to *S*, so as to form a cam. This cam, *R*, is of the same thickness as the catch, *T*, and works in the oval-shaped hole in *T* as shown in Fig. 64-*I*. The catch, *T*, is provided with a raised lug, *L*, which fits into a hole in *D* (Fig. 63). The plate, *D*, is not shown. in Fig. 64. The notched metal plate (*N*, Figs. 63 and 64) is held stationary by lugs which fit into slots in the porcelain base, *P*.

The spring (*E*, Fig. 63) has its upper end fastened to the shaft, and its lower end fastened to *D*. The tension in *E* tends to rotate *S* in the left-hand direction. However, *S* cannot rotate to the left because *R* bears

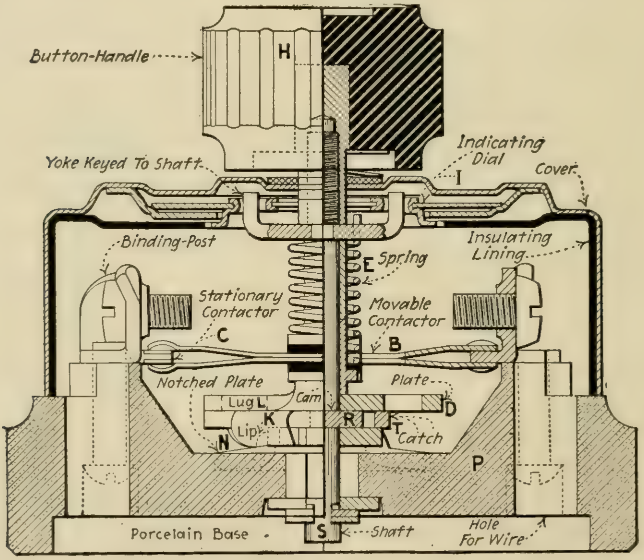


FIG. 63.—Rotating-button snap switch. (*Arrow Electric Co., List No.* 6207.)

against the side of the oval-shaped hole (Fig. 64-*I*) in *T*, and *T* is held stationary by *L* fitting into the hole in *D*. Since the tension in the spring tends to rotate the shaft to the left, it will tend to cause *D*—also *B*—to rotate to the right. Also, since *D* engages with *T* by means of the lug, *L*, *T* will have a tendency toward right-hand rotation. Right-hand rotation of *T* is normally prevented by the lip, *K*, which engages with the notch in *N* (Fig. 64-*I*).

The switch is operated by turning the button, *H*, to the right, or clockwise. This, as explained above, rotates the shaft, and likewise the cam, *R*. Rotation of the cam, *R*, causes *T* (Fig. 64) to swing about *L* as a center, until it reaches the position as shown in Fig. 64-*II*, at which position the lip, *K*, is disengaged from the notch in *N*. When this disengage-

ment occurs, T is free to move. Since T is free to move, D is also free to move. Thus, when T is released, the spring-tension, acting on D and consequently on B, "snaps" the movable contactor, B, to the right until K engages with the next notch in N, as shown at Fig. 64-*III*. Thus, the movable contactor has been rotated through an angle of 90 deg., or from one of its positions to the other. Since one operation of the switch causes both the movable contactor and the shaft to rotate in the same direction and through the same angle, they are, after operation, in the same relative position as before the operation. Thus, the spring-tension remains practically the same throughout any number of successive operations.

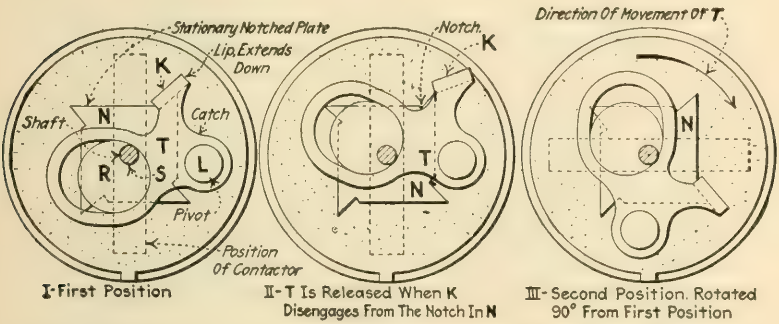


FIG. 64.—Illustrating operation of rotating-button snap switch. (*List No.* 6207, *Arrow Electric Co.*)

87. Another Type Of Rotating-button, Revolving-blade Snap-switch Mechanism is shown in Fig. 65. The spring, S, is fastened to the shaft, F, at A, and to the plate, D, at E. This plate, D, carries the movable contactor, B. The operation of this mechanism is illustrated in Fig. 66. To understand the operation, which is explained below, refer to both Figs. 65 and 66. The same reference letters are used on both illustrations, but on neither are all reference letters shown.

EXPLANATION.—The spring, (S, Fig. 65) which is "wound up," tends to rotate the lock-plate (D, Figs. 65 and 66) to the right as shown by the arrow in Fig. 66-I; and tends to rotate the shaft, F, to the left. But D cannot rotate to the right because the slot (G, Fig. 66-*I*) engages a projecting lug, H, on the catch, J. Furthermore, J cannot rotate because the hook K, bears against the stationary lug, L. The holding-plate, M, which carries the lug, L, is held stationary by the porcelain base. A flat circular metal piece, (N Fig. 66-*I*), is keyed to F, so that N is off

center, thus forming an eccentric. The shaft cannot rotate to the left because of a notch in N which engages a projection in J as shown in Fig. 66-*I*.

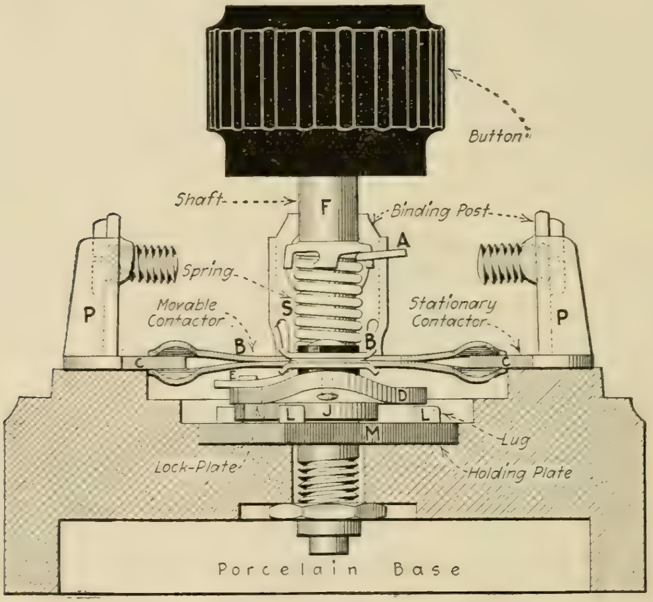


FIG. 65.—Showing mechanism of rotating-button, snap switch. (*Bryant Electric Co.*)

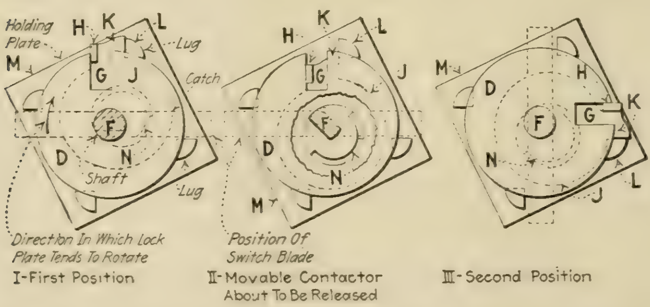


FIG. 66.—Illustrating the operation of the mechanism of a rotating-button, snap-switch. (*Bryant Electric Co.*)

In operating the switch, the button is turned to the right. This, through the eccentric, N, moves J downward, as shown in Fig. 66-*II*, until K is released from the lug, L. This leaves J and D free to rotate.

Since, as explained above, the spring tends to cause a right-hand rotation of *D*, *D* now turns to the right with a "snap," carrying the movable contactor, *B*, with it, until *K*, strikes the next lug, *L*, Fig. 66-*III*. The movable contactors have thus been rotated through an angle of 90 deg., or from one position to a second position.

88. Push-button Snap Switches May Be Classified as: (1) *A one-button snap switch.* (2) *A two-button snap switch.* Practically all one-button snap switches (Fig. 67) are of the revolving-blade type (Sec. 23). Whereas, the majority of the two-button snap switches are of the oscillating-blade type (Sec. 24). A push-button snap switch is sometimes called a *push switch.* Switches of each of the above-mentioned types are described in the following sections.

89. A One-button, Snap Switch Of The Push-button Flush Type, Which Has A Revolving-blade Mechanism, is shown in Fig. 67. The snap-action mechanism is identical with that described under Sec. 87 in connection with Figs. 65 and 66. However, the rotation of the shaft in Fig. 67, instead of being produced by turning a button, as in Figs. 65 and 66, is produced as follows:

EXPLANATION.—The push-button, *A*, Fig. 67, contains an internally-threaded sleeve which fits over the external threads on the shaft, *S*. The collar, *D*, is rigidly secured to the button. In each end of *D* is a slot which fits loosely over the posts, *E*. The posts, *E* are riveted into the sub-plate, *F*. Thus, the button, *A* cannot turn. Therefore, when *A* is pressed downward, *S* rotates. Rotation of *S* operates a dog- and-ratchet mechanism, contained in *R*. This dog-and-ratchet mechanism operates to rotate the main shaft of the switch. This rotation releases the snap-action mechanism. The rotation of the movable contactors then occurs as described in Sec. 87. The hollow button, *A*, contains a coil-spring which is compressed when the button is pushed inward. Then, when the outside pressure on the button is released, the spring expands and carries the button outward to the original position. Everything is then in readiness for a second operation.

90. Two One-button Snap Switches May Be Contained In A Single Porcelain Casing as shown in Fig. 68. The operation of each switch is the same as that described in Sec. 89. Each switch can be operated by its own button independently of the other switch. Practically any two forms of switches which are desired, such as two single-pole switches, one three-way

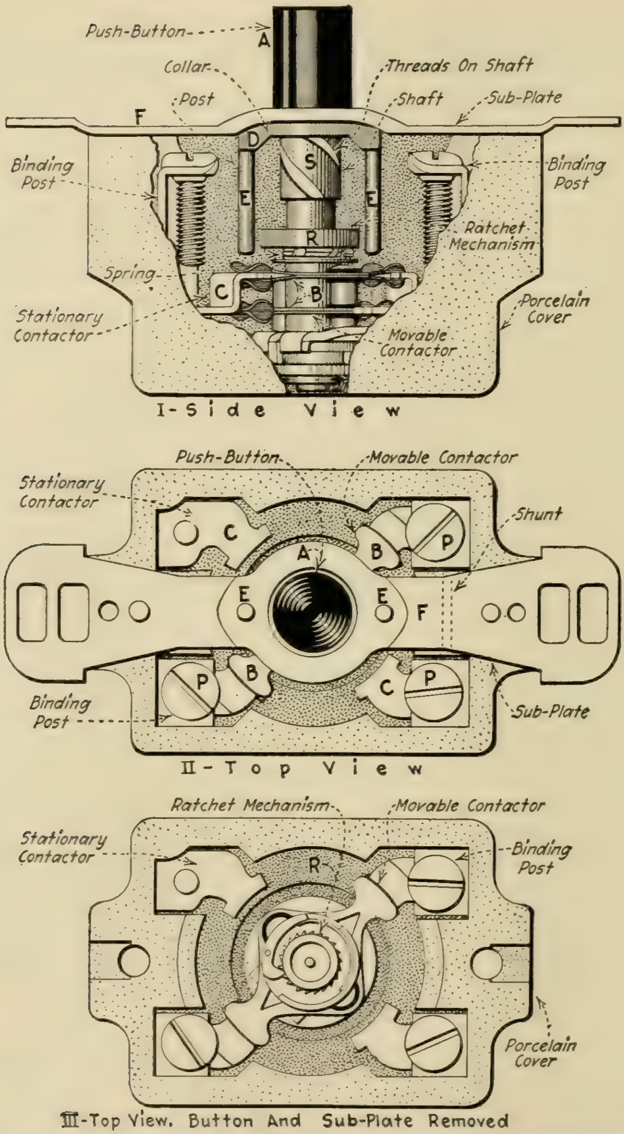


FIG. 67.—Push-button snap switch. (One-button, revolving-blade mechanism. *List No.* 2458, *Bryant Electric Co.*)

switch and one single-pole switch, one single-pole switch and one electrolier switch, and so on, may be used. The arrangement shown in Fig. 68 consists of two single-pole switches which have a common feed. That is, two of the stationary contactors are connected to the same binding-post.

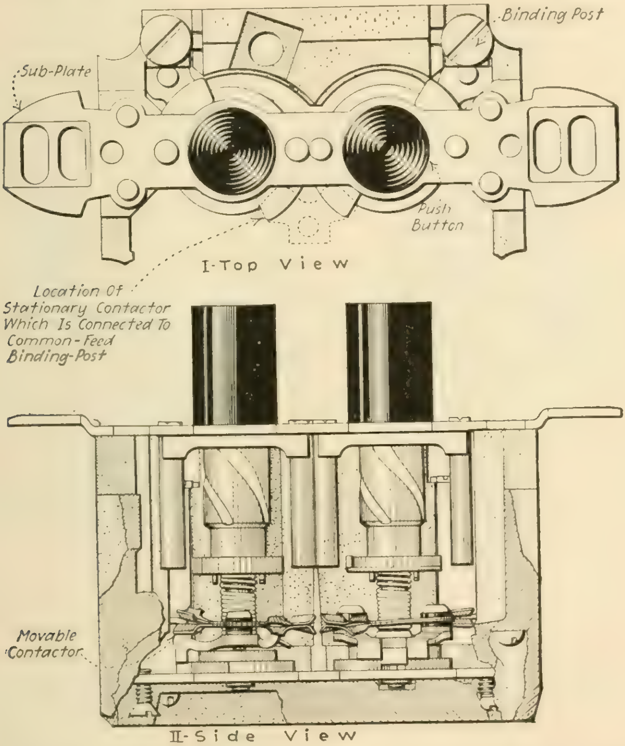


FIG. 68.—Two one-button, push snap-switches mounted in a single porcelain cover. (The illustration represents two single-pole switches having a common feed. *List No.* 2639, *Bryant Electric Co.*)

91. A "Release-catch" Two-button, Single-pole, Flush Snap Switch is shown in Fig. 69. As hereinbefore stated (Sec. 88), nearly all two-button snap switches are of the oscillating-blade type. That is, by pressing one of the buttons, the blade is caused to rotate with a quick snap action, through some arc of a circle—usually about 85 or 90 deg. Then by pressing the other button, the blade movement is reversed—

that is, it rotates through the same arc in the opposite direction. Thus, by pressing first one button and then the other, the blade, or blades, oscillate back and forth. As shown at *III*,

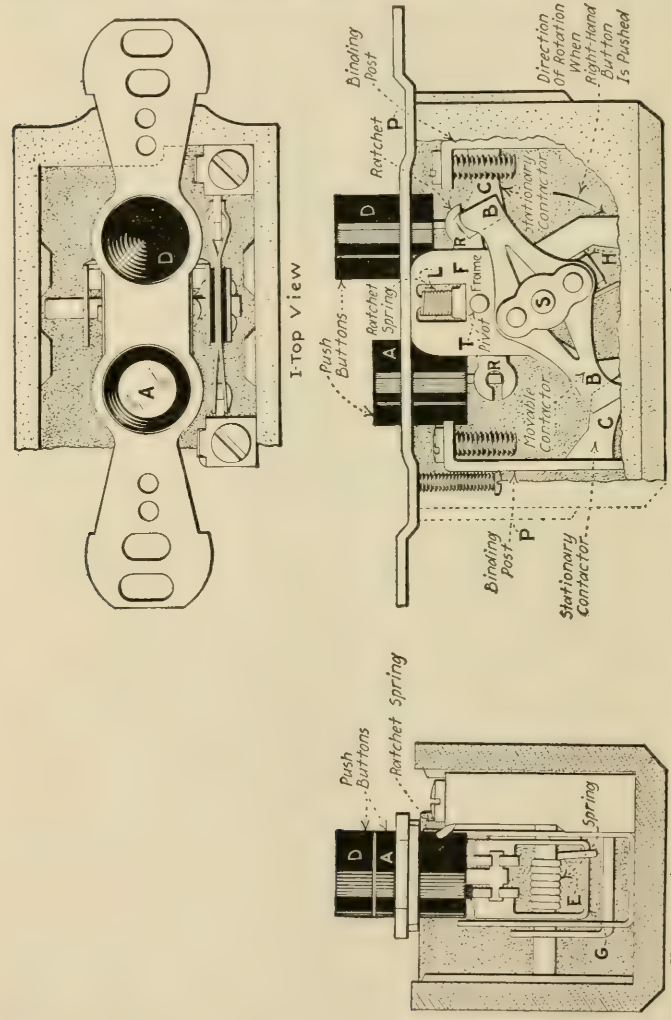


Fig. 69.—Releasing-catch type of two button, flush, snap switch. (*Bryant Electric Co.*)

Fig. 69, the switch is closed, or in the on-position. By pressing on the right-hand button, the rocker, *R*, rotates around the pivot *T*. This causes the movable contactor, *B*, to rotate,

in the direction shown by the arrow, through an angle of approximately 90 deg., about the shaft, *S*, as a center. Thus, after rotation *B* and *C* do not contact, and the switch is open. Then, by pressing the left-hand button, the action is reversed, and the switch is thereby closed. The operation is explained in detail below.

EXPLANATION.—The operation of the two-button, flush snap switch of Fig. 69 is illustrated in Fig. 70. The switch-parts in Fig. 70 bear the same reference letters as corresponding parts in Fig. 69. In Fig. 70-*I*, the switch is in the off-position, and is held there by the spring, *E*, as follows: One end of *E* presses to the left against the cross-piece, *G*, which

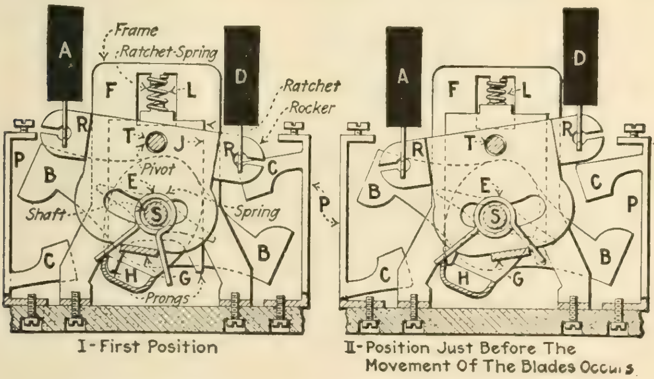


FIG. 70.—Illustrating operation of a two-button, flush, snap-switch mechanism of the release-catch type. (*Bryant Electric Co.*)

is carried by the rocker, *R*. The other end of *E* presses to the right against the cross-piece, *H*, which is carried by the movable contactor, *B*. The cross-piece, *H*, is prevented from moving to the right by the prong on the ratchet, *J*.

To operate the switch, button *A* is pushed downward. This action, by rotating the rocker, *R*, about the pivot *T*, carries *G* to the right as shown in Fig. 70-*II*. This movement of *G* to the right spreads the ends of the spring, thus increasing the tension therein. Also, as *R* is rotated about *T*, the ratchet, *J*, is caused to move upward, so that when *R* has almost reached its extreme position the prong of the ratchet slips out of *H* as shown at *II*. This leaves *H* free to move. Thus, *H* being free to move, the spring-tension rotates, with a vigorous snap-action, the movable contactor, *B*, around the shaft, *S*, as a center, until *H* strikes the frame as shown in Fig. 69-*III*. The switch is now in the on-position or closed. When the pressure on *A* is released—after the movable contactor, *B*, is in the position shown at *III*—the ratchet-spring, *L*, moves

in the position shown at *III*—the ratchet-spring, *L*, moves the ratchet downward so that the right-hand prong of the ratchet engages and holds *H* in the same manner as shown at Fig. 70-*I*. If button *D* is now pushed, the operation explained above is reversed, and the movable contactor will be rotated, in the opposite direction, to the open position.

92. A Lever-type, Two-button, Flush Snap-switch Mechanism is illustrated in Fig. 71. See also Fig. 83 and accompanying explanation. As shown at *III*, the movable contactor, *B*, and the stationary contactors, *C*, are in contact. Hence, the switch is closed. By pushing the left-hand push-button, the movable contactor, *B*, is caused to rotate with a quick snap-action movement through an angle of about 80 or 90 deg. Then, since *B* and *C* are no longer in contact the switch is open. A detailed explanation of the operation of this type of switch mechanism is given below.

Explanation.—The discussion which follows refers chiefly to Fig. 72. However, those reference letters which appear in both Figs. 71 and 72 are applied to corresponding parts. As shown in Fig. 72-*I*, the spring, *S*, acting on the rocker-cross-piece, *F*, and the movable-contactor-cross-piece, *G*, tends to push *F* upward and to the left, and it tends to push *G* downward and to the right. Therefore, this spring-pressure holds the movable contactor, *B*, in the position as shown at *I*. Assume that the stationary contactors (*C*, Fig. 71, not shown in Fig. 72) are so located that when *B* is in the position as shown in Fig. 72-*I*, the switch is closed, and is therefore, held by the spring in the closed position, as explained above.

By pressing downward on button *A*, the rocker, *R*, rotates about the pivot, *E*. This causes *F* to move downward and to the right, thus compressing the spring, as shown in *II*. As soon as *R* has rotated beyond the position of *II*, the spring tension acts to force *F* upward and to the right, and to force *G* downward and to the left. However, when *R* has reached the position shown in *II*, it is almost to the end of its travel. Therefore, the spring acting downward and to the left on *G*, moves *G* to the left with a "snap," until it reaches the position shown in *III*. This movement of *G* rotates the movable contactor, *B*, about a circular shoulder, *K*, which is carried by the stationary frame, *H*, to the position shown in *III*, thus opening the switch. To reclose the switch, the above-described operation is merely reversed.

93. A Two-button, Snap Switch, Which Has The Buttons Arranged In Tandem is shown in Figs. 73 and 74. This switch mechanism operates on the oscillating-blade principle (Sec. 91). Pushing one of the buttons causes the blade to rotate through about 90 deg. Pushing the other button

causes the same blade-rotation in the opposite direction. Thus, the switch is opened and closed. Each of these rotations occurs with a snap action as explained below.

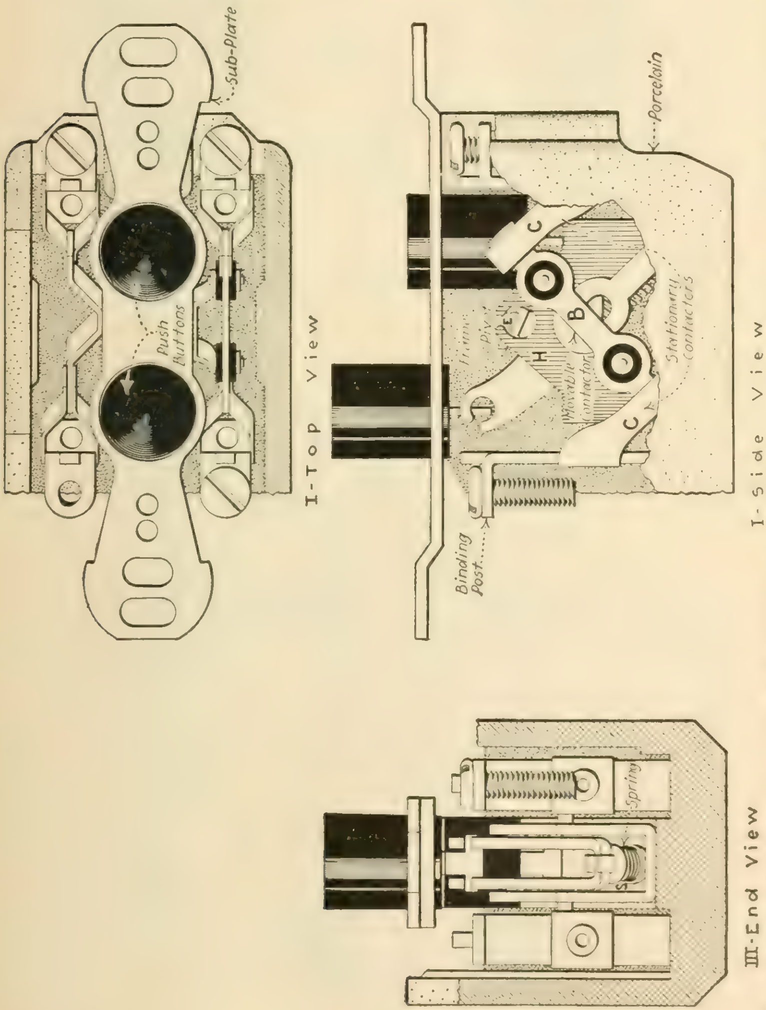


FIG. 71.—Lever-type, two-button, flush snap switch. (A part of the porcelain is broken out to show the mechanism. *Bryant Electric Co.*)

EXPLANATION.—The mechanism shown in Figs. 73 and 74 is (*Cutler-Hammer Mfg. Co.*) known as the "Hill-And-Valley" movement. The reference used in Figs. 73 and 74 refer to the same parts as those in

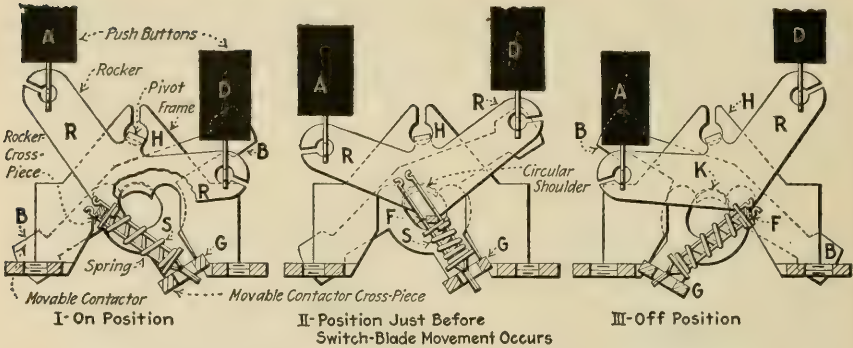


FIG. 72.—Illustrating operation of a two button, flush snap-switch mechanism of the lever-type. (*Bryant Electric Co.*)

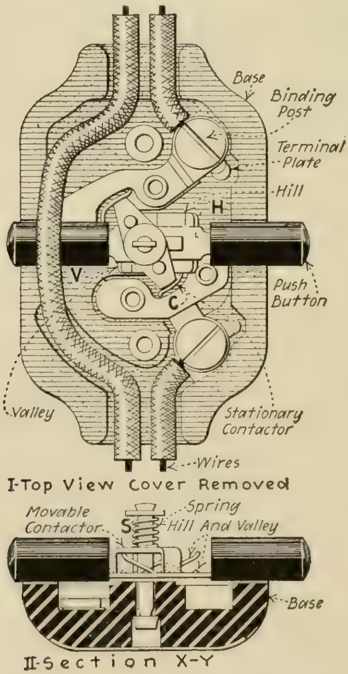


FIG. 73.—Tandem, two-button, straight-through snap switch. (*List No.* 7050, *Cutler-Hammer Mfg. Co.*)

Fig. 75. The movable contactor (*B*, Fig. 75) carries two lugs, *L*, one of which normally rests in the middle or lowest point of the valley, *V* (Fig. 75-*I*), and the other rests at the foot of the hill, *H*. This holds the blade in the open position shown at *I*.

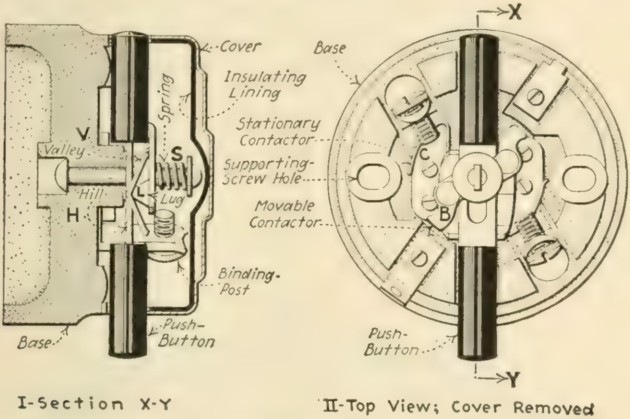


FIG. 74.—Single-pole, tandem, two-button, surface snap switch. (*List No.* 7108, *Cutler-Hammer Mfg. Co.*)

If the right-hand button is pushed to the left, the valley-lug slides up the side of the valley and the hill-lug slides up the side of the hill, as

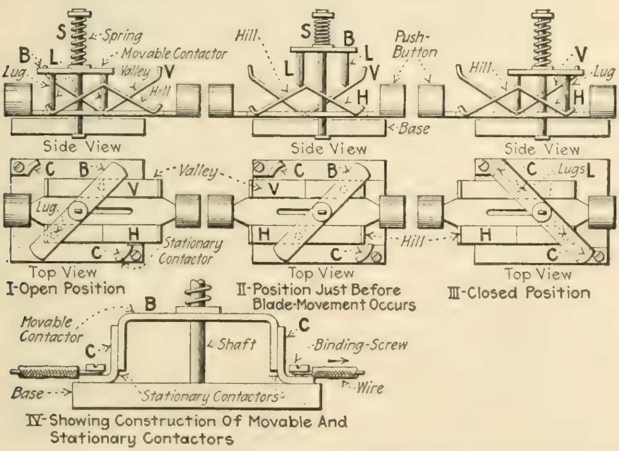


FIG. 75.—Illustrating the operation of the hill-and-valley snap-switch mechanism.

shown at *II*. This tends to rotate the upper end of *B* to the left (Top View, *II*), and also to rotate the lower end of *B* to the left. Consequently, no rotation can yet occur. However, the two lugs, *L*, one sliding

up the valley and one up the hill, do raise the movable contactor upward, thus compressing the spring, S, as shown in II. A consideration of IV will disclose how B may be raised and yet B and C still remain in contact with each other. When the button is pushed a little farther to the left than is shown at II, the hill-lug will slip over the top of the hill. The compressed spring (S, Fig. 75-II), pushing downward on B, then causes the hill-lug to slide down the hill and the valley-lug to slide back down the valley. This causes a quick snap-action rotation of B in a left-hand direction, thus closing the switch. If now the left-hand button is pushed to the right, the switch will be re-opened, by an operation which is just the reverse of that described above.

94. Another Tandem, Two-button, Snap Switch is illustrated in Fig. 76. Although the mechanism of the switch in Fig.

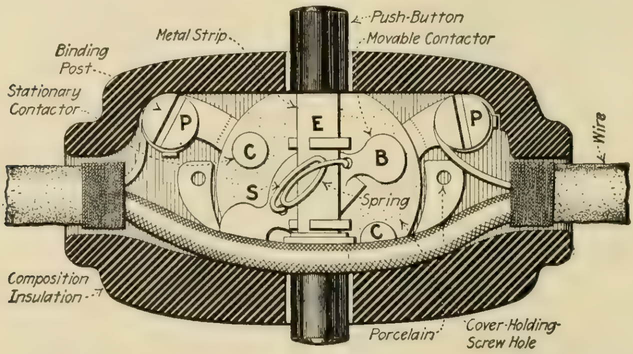


Fig. 76.—Top view, with cover removed, of tandem, two-button, single-pole, "feed-through" or straight-through snap switch. (*Beaver Machine & Tool Co.*)

76 is different from that of Figs. 73 and 74, the same general effect as that which is described in Sec. 93 is produced by pushing the buttons. A detailed explanation of the operation of the mechanism of Fig. 76 is described below.

Explanation.—The switch as shown in Fig. 76 is open. The spring, S, has one of its ends secured to the movable contactor, B, and the other end secured to the metal strip, E, which carries the push-buttons. When the switch is in the open position (Fig. 76), the spring being under tension, pushes downward and to the left on the movable contactor, B; and, at the same time, it pushes upward and to the right on the metal strip, E. This spring pressure holds B in the position shown. B is pivoted at its center.

By forcing the upper push-button downward, that end of the spring, S, which is secured to the metal strip, E, is also moved downward. This downward movement of the spring-end further compresses the spring,

thus increasing the tension therein. Also, this downward movement of the spring-end changes the direction of the force which the spring exerts on the movable contactor, B. When the spring-end which is carried by E has moved downward until it is below a horizontal line through the point where the other end of the spring is secured to B, the force on B is upward and to the left. As soon as the direction of the force on B becomes upward, B rotates with a snap action in the right-hand direction until the ends of B are in contact with the stationary contactors, C, whereupon the switch is closed. After this rotation, the spring is again in the same relative position with respect to B and C as it was before the switch was closed. The switch may be re-opened by a reversal of the above-described operation.

95. The One-button Door Switch of Fig. 77 is designed for installation in a door-jamb (see Div. 8), so that opening and

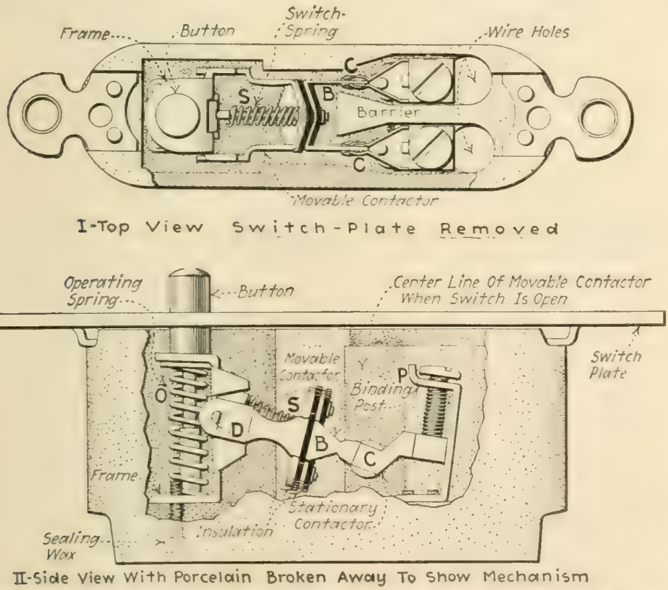


FIG. 77.—One-Button, single-pole door switch (*List No. 2355, Bryant Electric Co.*)

closing the door operates the switch. The switch, as shown (Fig. 77) is closed. Pressing downward on the button rotates, with a snap action, the movable contactor upward about the pivot, D, thus opening the switch. When the pressure on the button is released, the switch snaps closed. The operation of this mechanism is explained below.

Explanation.—The switch-blade snap-movement which occurs in the operation of the switch shown in Fig. 77 is identical with that which is described under Sec. 92 in connection with Fig. 72. That is, when the button (Fig. 33-*II*) is pushed downward, the upper end of the switch-spring, *S*, is rotated and compressed—as explained in Sec. 92 —until it acts upward on the movable contactor, *B*, thus rotating *B* with a snap to the open position shown by the dot-dash line in Fig. 77-*II*. When *B* is rotated to the open position, the tendency of the switch-spring, *S*, is—just as in Fig. 72—to hold it in this position. However, when the pressure on the button is removed, the tension in the operating-spring, *O*, which was compressed when the button was forced downward, overcomes the tendency of *S* to hold *B* open, and acts to push the button upward. Consequently, the switch is closed with a snap when the pressure on the button is removed. In other words, the operating-spring (*O*, Fig. 77-*II*) operates the switch—when the button-pressure is removed—in essentially the same manner as when button *D*, (Fig. 72-*II*) is pushed with the finger.

This type of switch is also made so that when the button is held "in" the switch is closed, and when the button is released, it is opened.

96. The Operation Of Momentary-contact Snap Switches (Figs. 78 and 79) is similar to that of the door switch (Sec. 95) in that each contact remains closed—or open—only while the push-button is held in. Momentary-contact snap switches are made in two different types: (1) *Those wherein the switch is normally open*, so that when the button is pressed inward, the movable contactor rotates, with a snap action, to the closed position. Then when the pressure on the button is released, the movable contactor rotates in the opposite direction to the open position. (2) *Those wherein the switch is normally closed*, so that pressing inward on the push-button opens the switch and removing the push-button pressure closes it—both the closing and opening operations occurring with a snap action. Some momentary-contact snap switches are so made (Fig. 79) that two switches, each having its own push-button, are mounted in the same porcelain cover. Thus, two separate circuits may (Div. 8) be controlled from the same location. The operation of the mechanism of a momentary-contact switch is explained below.

Explanation.—The normal position of the mechanism of a momentary-contact switch (porcelain casing removed) is shown in Fig. 78-*I*. The same mechanism with the movable contactor and the switch spring removed is shown at *II*. The ends, E_1 and E_2, of the switch spring, which is carried by the shaft, *S*, hold the switch in its normal position

shown at *I*, as follows: The end of the switch spring, E_1, tends to produce right-hand rotation of the arm, *A*, about shaft *M* as a center. As shown at *II*, the arm, *A*, is prevented from rotating to the right by the ends of the operating spring, *O*. The other end, E_2, of the switch spring (Fig.

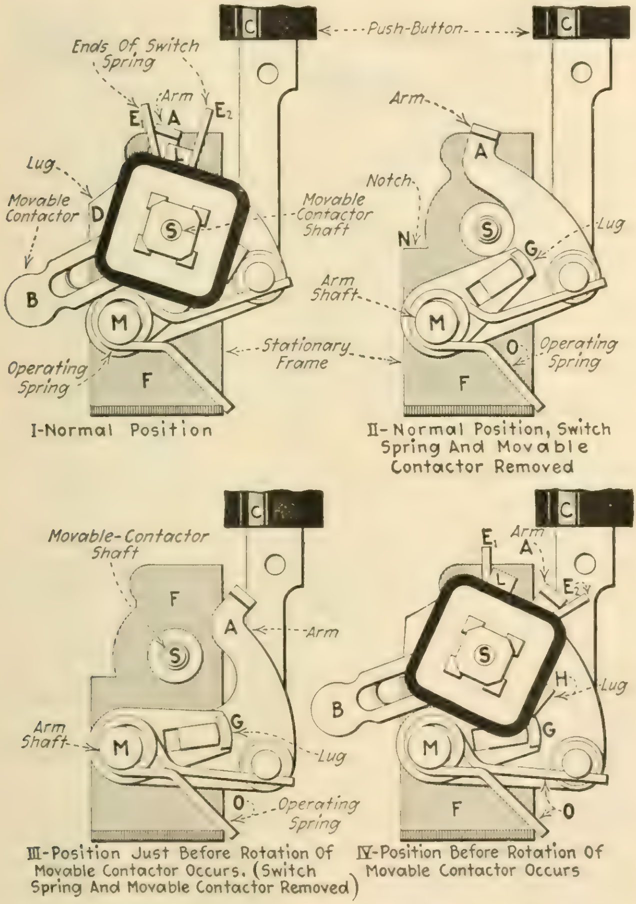


FIG. 78.—Showing operation of momentary-contact snap-switch mechanism. (*Hart & Hegeman Mfg. Co.*)

78-*I*) tends to produce left-hand rotation of the movable contactor, *B* (Fig. 80) by pushing to the left on the lug, *L*—*L* is rigidly fastened to *B*. Left-hand rotation of *B* is prevented by another lug, *D*—which is also carried by *B*—engaging in a notch, *N*, (Fig. 78-*II*) in the stationary frame, *F*.

When the push-button, C, is pushed downward, the arm, A, is rotated to the position shown in *III* and *IV*. As shown in *IV*, the lug at the upper end of A spreads the spring-ends, E_1 and E_2, apart, thus tending to rotate B to the right and at the same time increasing the tension in the switch spring. (When there is no force exerted on the switch spring the normal distance between the ends, E_1 and E_2, is approximately equal to the width of the lug, L.) Rotation of B cannot yet occur because of lug H, (Fig. 78-*IV*) which is carried by B, striking lug G, which is on arm A. When A is rotated to the right a little farther than is shown at *IV*, H slips over G, and the tension in the switch spring causes a snap-action rotation of B to the position shown in Fig. 79-*I* and 80-*II*.

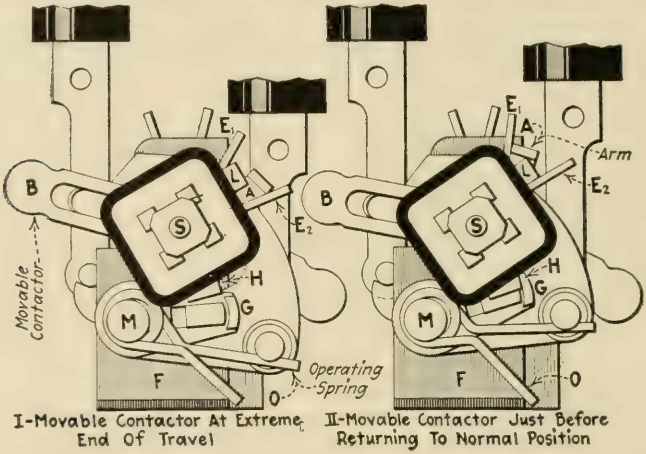


FIG. 79.—Showing operation of nomentary-contact snap-switch mechanism. (Two mechanisms are shown mounted back to back, thus two switches may be contained within a single porcelain casing. (*Hart & Hegeman Mfg. Co.*)

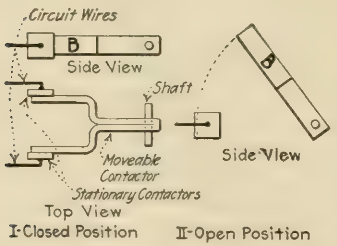
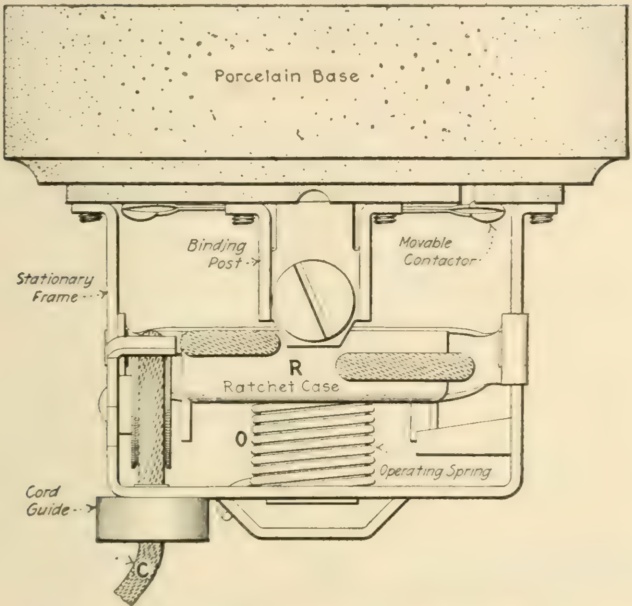
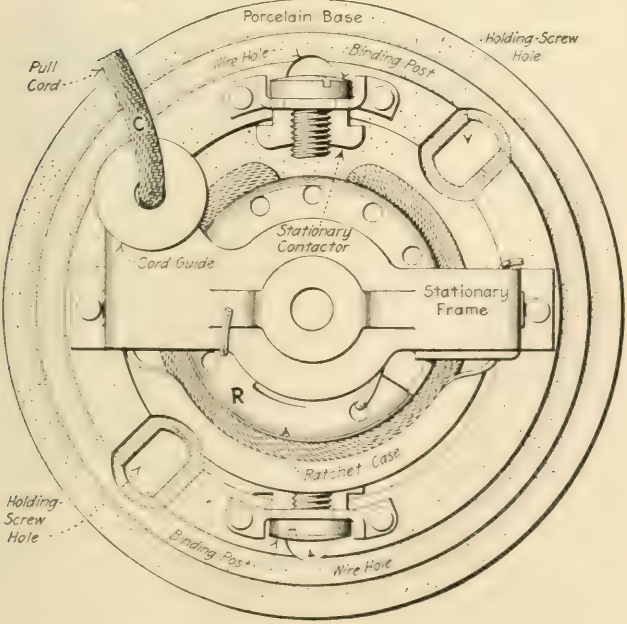


FIG. 80.—Illustrating the general arrangement of the movable contactor of a momentary contact switch.

When the pressure on the button is released, the operating spring, O, which was compressed when the button was pushed inward, causes A to rotate to the left (Fig. 79-*II*). Arm A, thus pushing against E_1, tends to produce, through E_2 and L, left-hand rotation of B. However, B cannot yet rotate because of H striking G, as in Fig. 79-*II*. When A rotates a little farther to the left than shown in *II*, G slips off of H, and the switch-spring ends, E_1 and E_2, rotate B with a quick snap action back to the position shown in Fig. 78-*I*.

The general shape of the movable contactor, B, is illustrated in Fig. 80,





II-Bottom View

FIG. 81.—Ceiling-type, pull switch with cover removed. (*Bryant Electric Co.*)

97. The Switch Mechanism Employed For The Snap Operation Of The Pull Switch of Fig. 81 is the same as that described in Sec. 89 in connection with Figs. 65 and 66. However, the shaft-rotation necessary to cause the operation of the switch mechanism is, in the pull switch (Fig. 81), produced by pulling a cord or chain, instead of by turning a button as in Fig. 65. Pulling the cord, *C*, rotates a ratchet mechanism contained in the ratchet-case, *R*, and at the same time winds up the operating spring, *O*. The ratchet mechanism engages the switch shaft and causes it to rotate far enough to operate the snap-switch mechanism. When the cord is released, the operating-spring, *O*, unwinds, and rotates the ratchet-mechanism in the opposite direction, so that it is again in readiness to engage the shaft for the next operation.

98. Various Operating Mechanisms Are Employed In Toggle Switches (Fig. 82). See Sec. 32. The method of operation of one type of toggle switch may be understood by a consideration of Fig. 83. Pushing the handle, *H*, of the toggle lever backward and forward produces exactly the same effect as alternately pressing the buttons of the switch described in Sec. 92.

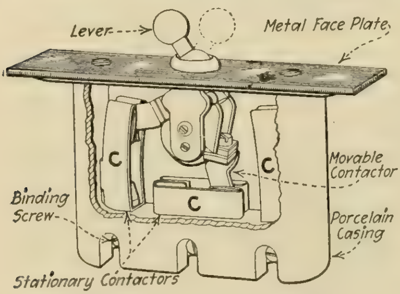


Fig. 82.—Flush-type toggle or tumbler switch.

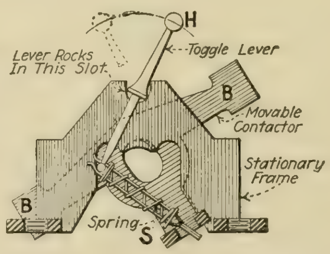


Fig. 83.—Illustrating operation of toggle or tumbler snap switch.

99. Snap Switches Are Manufactured In Several Different Forms. The more general forms are: (1) *Surface.* (2) *Flush.* (3) *Pendent.* (4) *Straight-through.* (5) *Canopy.* Various applications of each of the above-listed forms are discussed in the following sections.

Note.—Snap Switches, Which Embody The Various Types Of Operating Methods Previously Described Herein, Are Manufactured In Different Forms as outlined above. The types of operating

methods as applied to different snap-switch forms (Figs. 84 to 100 inclusive) are outlined in Table 100. The third column of Table 100 gives the number of the illustration wherein each of the various forms is illustrated.

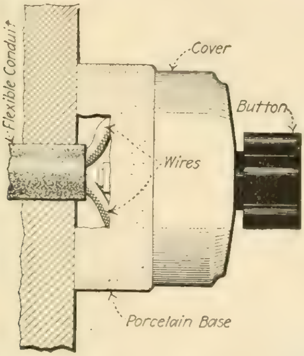


Fig. 84.—Rotating-button, surface snap switch. (*General Electric Co.*)

100. Table Showing Different Forms In Which Snap Switches Of The Various Types Of Operating Methods Are Manufactured.

Type of operating method	Form		Illustrated in Fig. No.
Rotating-button..........	Surface		84
	Flush		85
	Canopy		98
Push-button..............	Surface		86
	Flush		87
	Pendent		24 and 95
	Straight-through		96
	Canopy		99
Pull-chain or cord.........	Surface	Ceiling	22, 81 and 88
		Wall	89
	Canopy		100
Toggle..................	Surface		90
	Flush		91
	Straight-through		97

101. The More General Application Of Surface And Flush Snap Switches (Figs. 84, 85, 86, 87, 88, 89, 90, and 91) is for mounting on the wall near the entrance-door of a room or

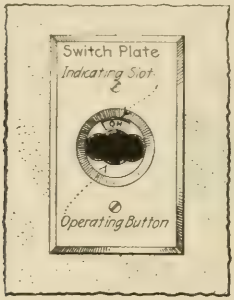


Fig. 85.—Rotating-button, flush snap switch. (*General Electric Co.*)

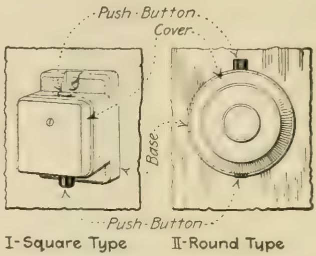


Fig. 86.—Push-button, surface snap switches. (*Cutler-Hammer Mfg. Co.*)

hallway for the control of lamps which are within that room or hallway, or for the control of lamps within a room or hallway adjacent thereto. *Pull-chain, ceiling- and wall-type, surface switches* are generally used for controlling lamps which are

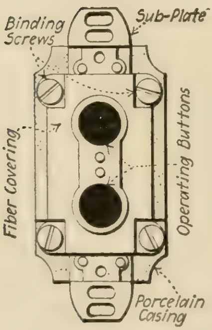


Fig. 87.—Push-button, flush snap switch with switch plate removed. (*Bryant Electric Co.*

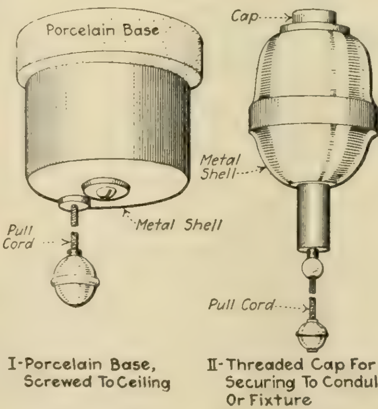


Fig. 88.—Pull-chain, ceiling snap switches. (*Bryant Electric Co.*)

mounted (Fig. 92) at a considerable height above the floor. This method of control of such a lamp-installation will usually require less wire than that for a pendent switch, or a rotating-

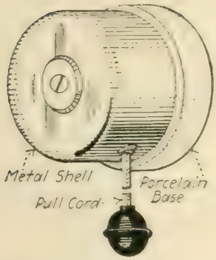


FIG. 89.—Pull-chain, wall snap switch. (*Bryant Electric Co.*)

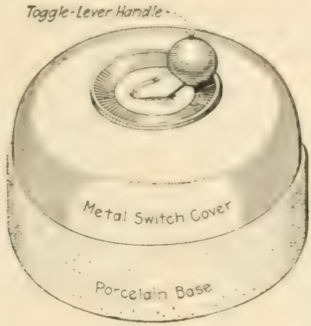


FIG. 90.—Toggle or tumbler surface snap switch.

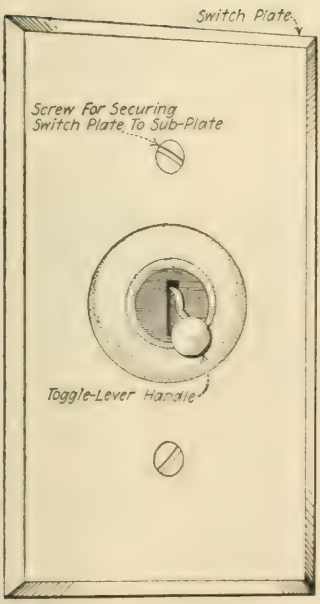


FIG. 91.—Toggle or tumbler flush snap switch. (*Hart & Hegeman Mfg. Co.*).

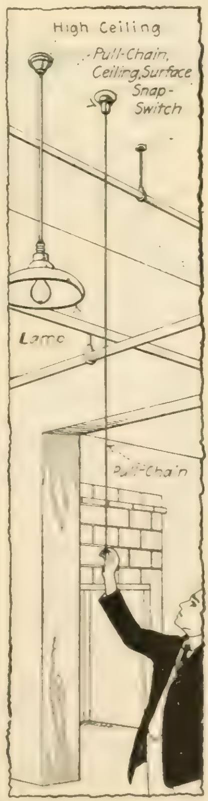


FIG. 92.—Pull-chain ceiling snap switch used to effect a wire saving by eliminating a double-run of wire to a location which could be reached from the floor.

or push-button switch, which is so mounted that it may be reached from the floor.

Note.—What Is Essentially Two-location Lamp-control May Be Provided By A Pull-cord, Ceiling Single-pole Snap Switch as suggested in Fig. 93. At a small cost many of the advantages of a set of three-way switches can be secured by placing the upstairs hall light on a ceiling pull-cord switch, so placed that the cord may be conveniently reached both upstairs and downstairs. Where the cord cannot be dropped directly from the second floor ceiling to the first floor, the cord can often be carried along the wall of the stairway, using small screw eyes

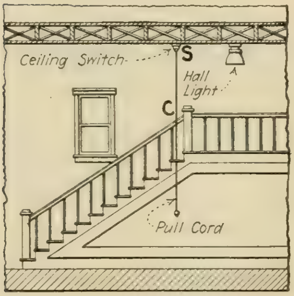


Fig. 93.

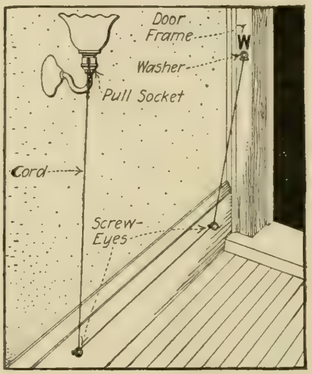


Fig. 94.

Fig. 93.—Pull-cord, snap switch, S, so mounted that switch may be operated from two floors by pulling the cord or chain, C.

Fig. 94.—Showing how an extension may be made for a pull-socket so that a wall bracket lamp may be controlled from door. A washer, W, is secured to the end of the cord to prevent its slipping through the screw-eye. Often bell cranks can be profitably employed at each location where the cord direction changes, instead of the screw eyes as above shown.

as guides. In Fig. 94, screw eyes are fastened in the baseboard and in the door facing as shown. A string, which is connected to the pull-cord of the socket, is guided to the door by the screw-eyes. The wall lamp may then be controlled from the door.

102. The Most-frequent Use Of Pendent Snap Switches (Fig. 95) is, probably, for the control of a single lamp, or of several lamps on one fixture, which are mounted at a considerable distance above the floor. The total installation-cost of a pendent switch is usually greater than that of a pull-chain switch, but less than that of a surface or flush switch mounted

on the side-wall. Pendent switches may sometimes be used advantageously instead of pull-chain switches in locations where the pull-cord of a pull-chain switch would not hang vertically in a straight line from the switch.

Note.—Probably, For Most Installations, The Pull-chain Switch Is Preferable because of its lower installation-cost and the fact that the chain or small-diameter pull cord which it requires casts a smaller shadow than does the lamp cord and switch of the pendent-switch arrangement. Probably, also, the pull-chain switch is the more sightly and involves the lesser maintenance cost.

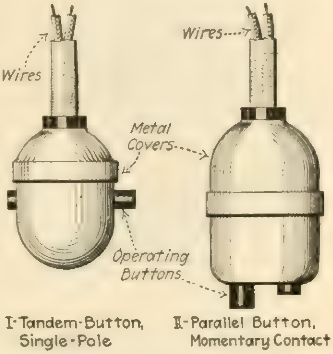


Fig. 95.—Push-button pendent snap switches. (*Bryant Electric Co.*)

103. The Use Of Straight-through Snap Switches (Figs. 96, and 97) is confined almost wholly to the control of those

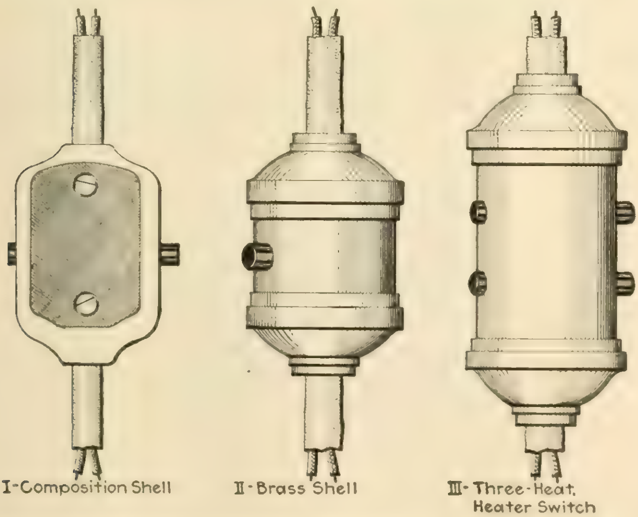


Fig. 96.—Push-button straight-through snap switches. (*Cutler-Hammer Mfg. Co.*)

devices such as floor lamps, table lamps, flat-irons, toasters, percolators, soldering irons, small motors, and the like, which

are served by a flexible cord. The straight-through switch may be installed anywhere on the flexible cord. For those devices mentioned above, which are not ordinarily equipped with switches, a straight-through switch installed on the cord near the device, provides a convenient control-location therefor.

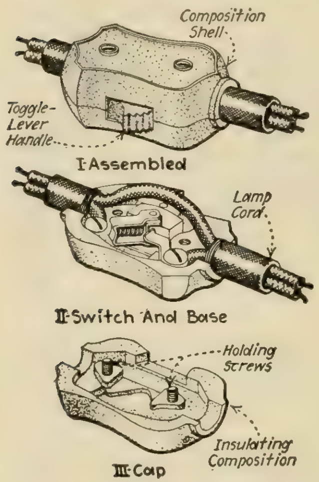


FIG. 97.—Straight-through toggle snap switch. The operation of this is substantially the same as Fig. 83. (*List No.* 3000, *Bryant Electric Co.*)

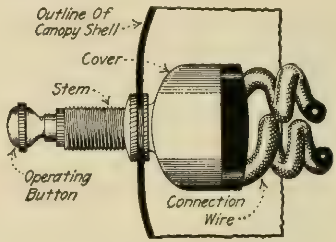


FIG. 98.—Rotating-button canopy switch. (*Bryant Electric Co.*)

104. The Use Of Canopy Switches (Figs. 98, 99, and 100) is, as the name implies, for the control of lamps or fixtures which

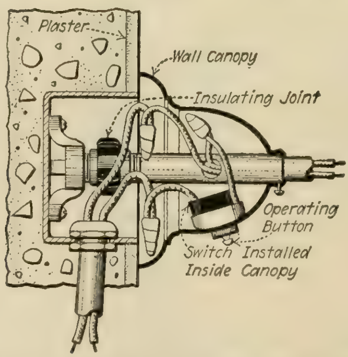


FIG. 99.—Push-button canopy switch for wall canopy, showing installation and connections.

are provided with a canopy. Since they are installed on the inside of the canopy (Figs. 99 and 100) practical considera-

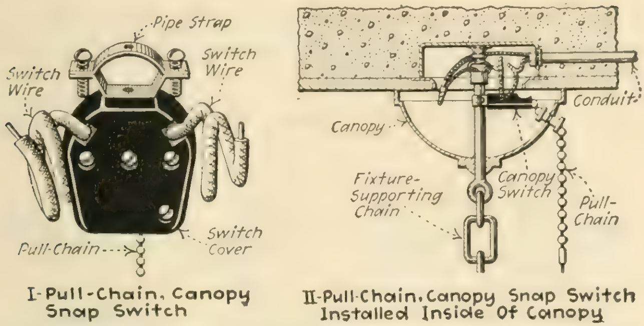


FIG. 100.—Pull-chain, canopy snap switch for ceiling canopy. (*List No.* 655, *Bryant Electric Co.*)

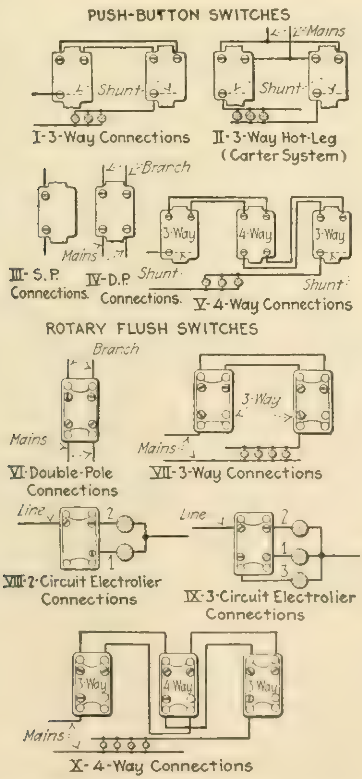


FIG. 101.—Flush snap switch wiring diagrams. (*The Hart Mfg. Co.*)

tions necessitate that they be small and compact in construction. Their rating seldom exceeds 6 amp. at 125 volts.

NOTE.—VARIOUS SNAP-SWITCH WIRING DIAGRAMS are shown in Figs. 101, 102, 103, 104.

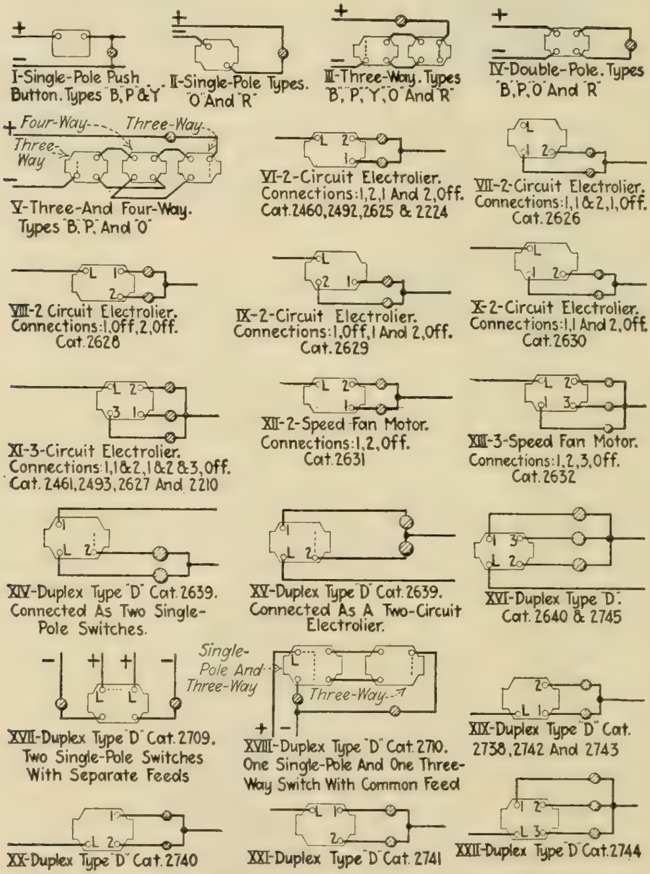


FIG. 102.—Wiring diagrams for flush switches. (*Bryant Electric Co.*)

105. A Circuit-connection Classification Of Snap Switches may be made according to the number of conductors which may be disconnected by them, and according to the sequence or method of making or breaking the several connections, as follows: (1) *Single-pole.* (2) *Double-pole.* (3) *Three-pole.*

(4) *Three-way.* (5) *Four-way.* (6) *Two-circuit electrolier.* (7) *Three-circuit electrolier.* (8) *Series-parallel.* Several of the more-commonly used circuit connections and the arrangement of the switch current-carrying parts (Sec. 80) for obtain-

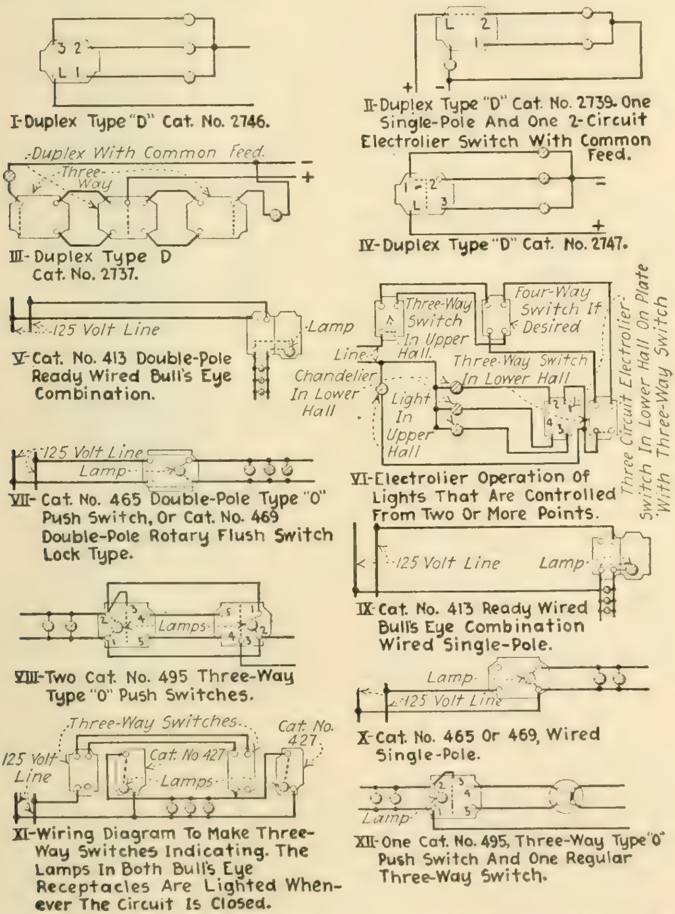


Fig. 103.—Wiring diagrams for flush switches—continued. (*Bryant Electric Co.*)

ing them are discussed in the following sections (see also Div. 1.)

106. A Single-pole Snap Switch Has One Movable Contactor And Two Stationary Contactors (B and C, Fig. 105),

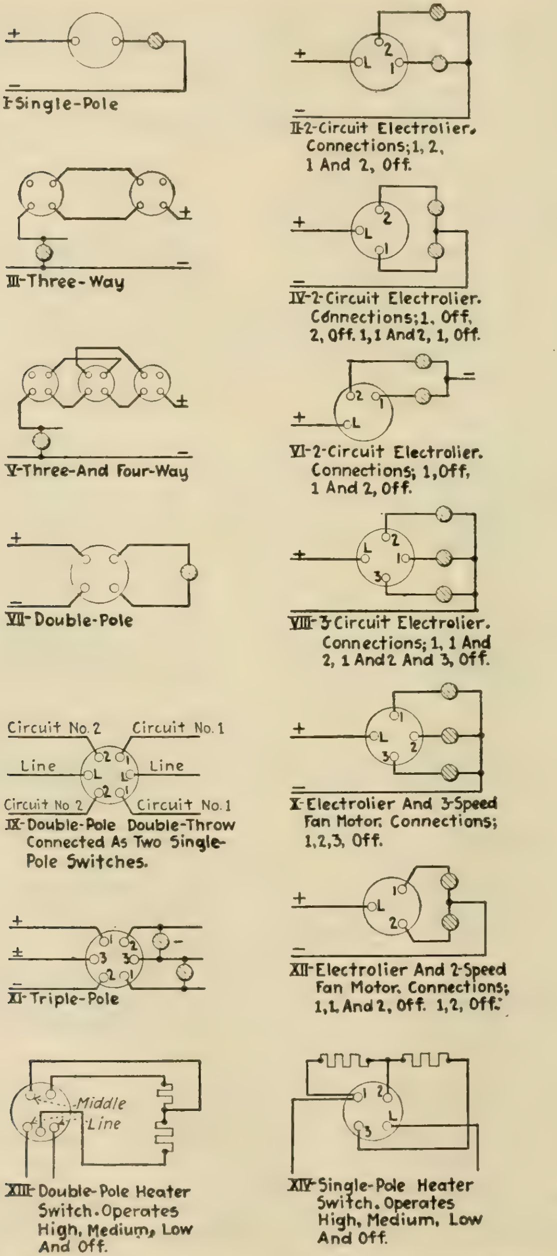


Fig. 104.—Wiring diagrams for surface switches. (*Bryant Electric Co.*)

so arranged that when the blade, or movable contactor, B, is in one position (Fig. 106-*I*) it does not touch the stationary contactor, C. In the other position (Fig. 106-*II*), the blade, B, touches both of the stationary contactors, C, and current may then flow through the switch from one wire to the other. The current-carrying parts of single-pole, flush snap switches are arranged in essentially the same manner as those of the surface switch.

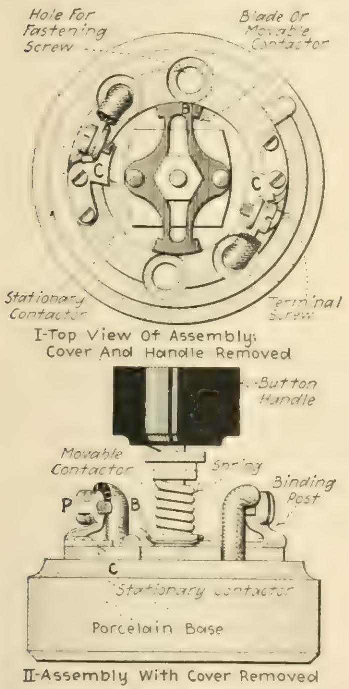


Fig. 105.—Single-pole, surface snap switch. (*Trumbull Electric Mfg. Co.*)

107. "Double-deck" Is A Descriptive Term Which Is Applied To A Surface Snap Switch when the switch has two movable contactors (LM and UM, Fig. 107), one of which is located above the other. That is, the two movable contactors of a double

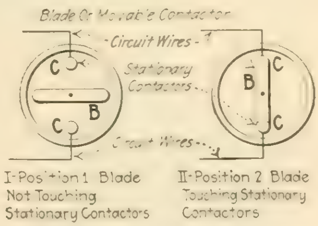


Fig. 106.—Circuit connection of single-pole snap switch.

deck, surface snap switch lie in two parallel planes which are perpendicular to the switch shaft. These two movable contactors may, or may not be insulated from each other. Each movable contactor of the double-deck switch has one or more stationary contactors (LS and US, Fig. 107), located in its respective plane. These stationary contactors may or may not be electrically-connected to each other by an internal shunt. Double-pole, three-pole, four-way, electrolier, and series-parallel surface snap switches frequently employ the double-deck construction. See following sections.

Some switches employ three decks and are then of *three-deck*

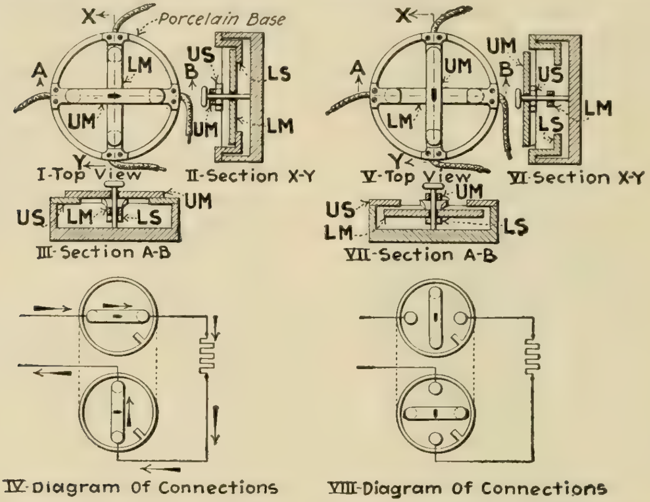


FIG. 107.—Illustrating arrangement of a double-deck, double-pole, surface snap switch.

construction. Theoretically, switches may employ any number of decks or be of *multi-deck construction.*

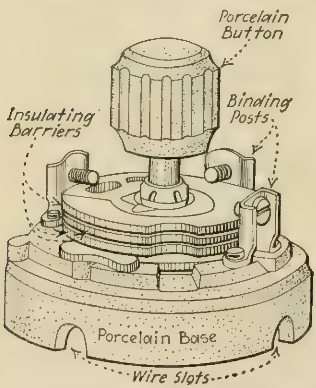


FIG. 108.—Double-deck snap switch for highly inductive circuits which is provided with barriers of insulating fibre to prevent a dangerous arc from being formed when the circuit is broken.

NOTE.—ALTHOUGH THE MOVABLE-AND-STATIONARY-CONTACTOR ARRANGEMENT OF FLUSH SNAP SWITCHES OF THE OSCILLATING-BLADE (SEC. 24) TYPE IS FREQUENTLY SUCH AS TO COMPLY WITH THE ABOVE DEFINITION OF A DOUBLE-DECK SWITCH, the term "double-deck" is not usually applied to oscillating-blade snap switches. It is usually applied only to revolving-blade switches.

NOTE.—FOR USE ON HIGHLY-INDUCTIVE CIRCUITS, MULTI-DECK SNAP SWITCHES ARE FREQUENTLY PROVIDED WITH BARRIERS of insulating fibre (Fig. 108). Thus, discs of insulating fibre are placed, one above, one below, and one between each deck, thereby preventing the e.m.f. of self-induction from establishing a dangerous arc upon breaking the circuit by opening the switch. See Sec. 130 for "barriers" for knife switches.

108. Double-pole Snap-switch Construction Usually Consists Of Two Movable Contactors And Four Stationary Contactors (Figs. 109, 110, and 111). The double-pole

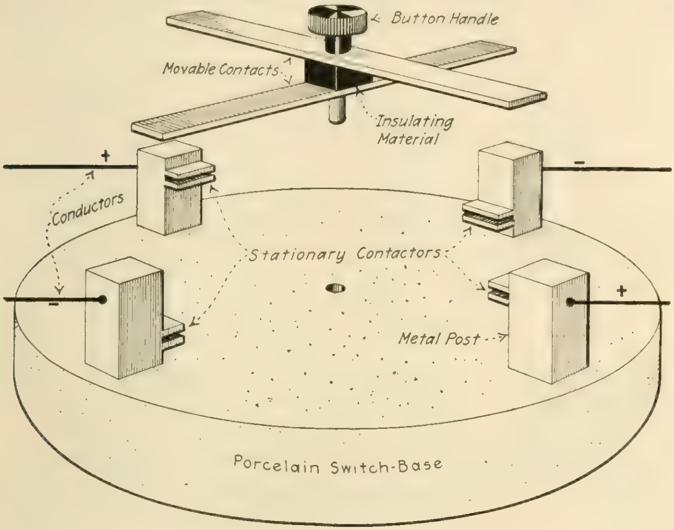


Fig. 109.—Illustrating principle of double-pole snap switch.

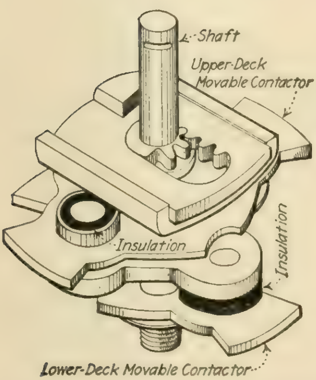


Fig. 110.—Showing one arrangement of a movable contactor in a double-deck, double-pole, revolving-blade snap switch.

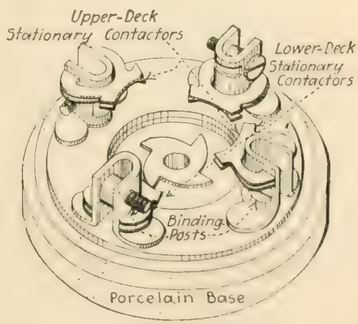


Fig. 111.—Showing arrangement of stationary contactors and binding-posts for a double-deck, double-pole, revolving-blade, snap switch.

revolving-blade type of switch is ordinarily constructed in the double-deck arrangement as illustrated in Fig. 107. The upper-

deck movable contactor (*UM*, Fig. 107-*I*) is at right-angles to, and insulated from the lower-deck movable contactor, *LM*. For each movable contactor there is one pair of stationary contactors, so arranged that when the switch is in the position shown in Fig. 107-*I*, the upper-deck stationary contactors, *US*,

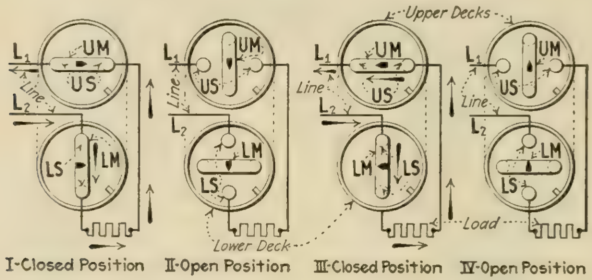


FIG. 112.—Showing circuit-connections of double-pole surface snap switch. (Beginning with *I*, four operations causes switch to resume position *I*. Current path is indicated by arrows.)

touch the upper-deck movable contactor, *UM*, also, the lower-deck stationary contactors, *LS*, touch the lower-deck movable contactors, *LM*. Thus, the switch is closed, and current may flow as indicated by the arrows in the diagram of connections,

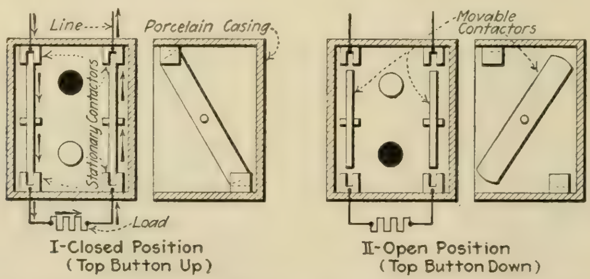


FIG. 113.—Illustrating circuit-connections of an oscillating-blade, two-button, double-pole, flush snap switch.

IV. When the switch is in the position shown in Fig. 107-*V*, *UM* and *LM* do not touch either *US* or *LS*; the switch is open, both wires which connect to the load are disconnected from the line, and consequently no current can flow. The circuit-connections of the switch for four successive operations of the button-handle are shown in Fig. 112. *The circuit-*

connections for an oscillating-blade, two-button, double-pole, flush snap switch are shown in Fig. 113.

109. An Arrangement Of The Current-carrying Parts Of, And The Circuit-connections For A Three-pole, Surface Snap Switch is shown in Fig. 114. It has three movable contactors, each being located in a separate deck. Therefore, it is a three-deck switch. For each movable contactor there are two stationary contactors which are located diametrically opposite one another and at the proper height or elevation to contact only with their movable contactor. That is, the upper-deck stationary contactors will contact only with the upper-deck movable contactor; the middle-deck stationary

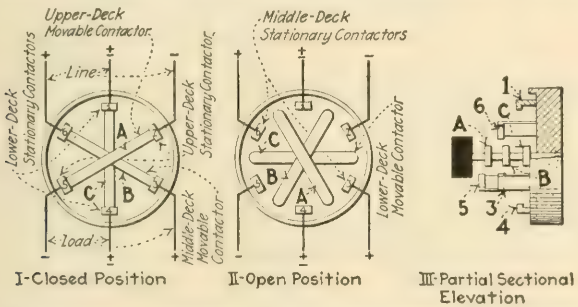


FIG. 114.—Positions and arrangement of current-carrying parts for a three-pole snap switch.

contactors will contact only with the middle-deck movable contactor, and so on. The movable contactors are insulated from each other. Also, the stationary contactors are separated by insulation. The switch—which is a two-position switch (Sec. 41)—is shown in the closed position in Fig. 114-*I*. One operation of the handle rotates the movable contactors through an angle of 90 deg. to the open position at *II*. The next operation would cause another 90-deg. rotation and the switch would again be in the closed position as shown at *I*, the movable contactors having been rotated 180 deg. from *I*.

110. A Typical Arrangement Which Is Employed In The Construction Of Three-way, Revolving-blade Snap Switches consists of one movable contactor (*B*, Fig. 115-*V*) and four stationary contactors, *C*. Two of the stationary contactors are connected together by a shunt, *S*, within the switch. The

binding-post is usually omitted from one of the shunted stationary contactors. Thus, there are only three binding-posts on a three-way switch. As illustrated in the diagram of circuit-connections (Fig. 115) the movable contactor is,

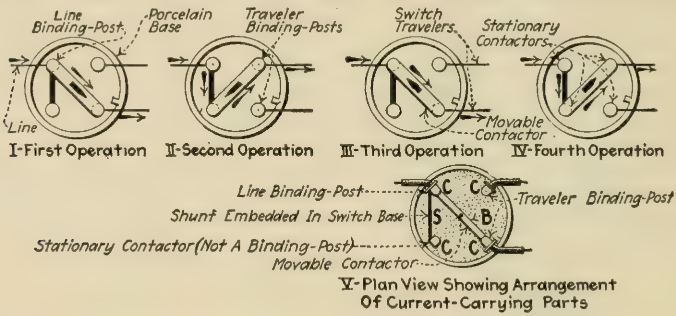


FIG. 115.—Illustrating typical construction and circuit-connections of a three-way, surface snap switch. (Arrows indicate possible current paths.)

except during operation, always touching two diametrically-opposite stationary contactors. Therefore, there is always an electrical connection between a line binding-post and one or the other of the traveler binding-posts.

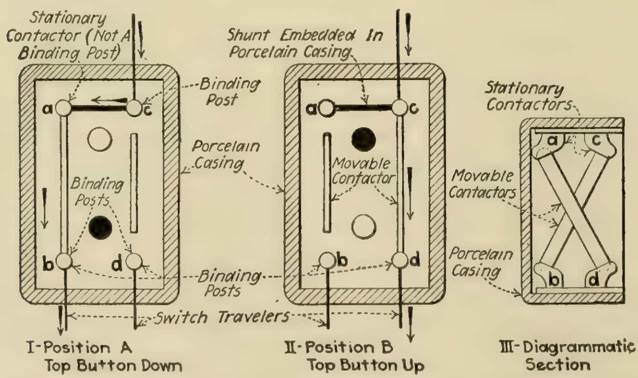


FIG. 116.—Positions and construction of a three-way flush snap switch of the oscillating-blade type. (Arrows indicate possible current-paths. The black filled-in circle represents a push-button up or out. The white circle represents a push-button down or in.)

EXPLANATION.—One operation of the button-handle causes the movable contactor (Fig. 115) to rotate through an angle of 90 deg. If, then, with the first operation of the switch-handle, the movable

contactor is in the position shown at Fig. 115-*I*, its positions for successive operations will be as shown at *II*, *III*, and *IV*. The possible current-path for *I* and *II* is the same as that for *III* and *IV*, although the movable-contactor in *III* and in *IV* has been rotated 180 deg., respectively, from *I* and from *II*. It is a two-position switch (Sec. 41); one position is shown in *I* and *III*, and the other position in *II* and *IV*.

NOTE.—THE CIRCUIT-CONNECTIONS AND TYPICAL CONSTRUCTION-ARRANGEMENT OF THE CURRENT-CARRYING PARTS OF THREE-WAY FLUSH SNAP SWITCHES OF THE OSCILLATING-BLADE TYPE are illustrated in Fig. 116. The same circuit connections are herein provided as in a three-way surface switch (Fig. 115).

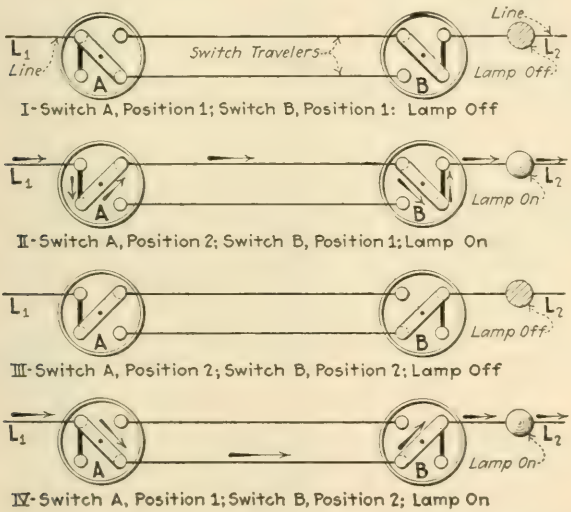


FIG. 117.—Showing possible circuit-connections effected by two three-way switches connected for two-location lamp-control.

NOTE.—THE FOUR POSSIBLE CIRCUIT-CONNECTIONS PROVIDED BY TWO THREE-WAY SNAP SWITCHES CONNECTED FOR TWO-LOCATION LAMP-CONTROL is illustrated in Fig. 117. As shown at *I*, the lamp is off. By operating switch *A*—practically all revolving-blade switches turn in right-hand direction only—*II* results and the lamp will be on. Or, by operating switch *B*, *IV* results, and the lamp will be on. Similarly, by tracing out the circuit-connections provided by the other possible switch-blade positions, it will be evident how the lamp may, with either *A* or *B* in any position, be turned either on or off by either *A* or *B*. Although the diagram in Fig. 117, is shown for a three-way surface switch (Fig. 115), the principles outlined therein are essentially the same as those for a three-way flush switch (Fig. 116, see also Div. 5).

111. A Typical Construction-arrangement Of The Current-carrying Parts, And The Various Circuit-connections Through A Four-way, Revolving-blade Snap Switch are shown in Fig. 118. The switch (Fig. 119-*I*) has four binding-posts. Each binding-post has two stationary contactors (C_1 and C_2, Fig. 119-*II*), one located in the upper deck, and one in the lower deck. The two movable contactors are of the form shown at *III* in Fig. 58. These two contactors (B_1 and B_2, Fig. 119), are located, one in the upper deck and one in the lower deck, and are insulated from each other. They are (Fig. 58-*III*) so shaped that each movable contactor always, except during operation, makes contact with two adjacent binding-posts. Successive operations of the switch causes the movable

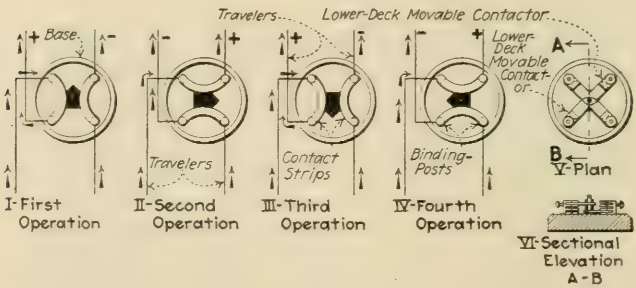


FIG. 118.—Positions of successive operations and construction of a four-way snap switch.

contactors to rotate through an angle of 90 deg., as shown in Fig. 118. The possible current-paths through the switch are indicated by the arrows.

NOTE.—MOVABLE-CONTACTOR POSITIONS OF FOUR-WAY, OSCILLATING-BLADE, FLUSH SNAP SWITCHES are shown in Fig. 120. Four-way, flush snap switches provide the same circuit-connections as do four-way surface snap switches (Fig. 118, see also Div. 5).

NOTE.—A FOUR-WAY SWITCH IS A COMMUTATING SWITCH. That this is true will be evident from a consideration of the polaraties shown in Fig. 118. That is, in alternate positions, it changes the current direction in the circuit feeding from it. In *I* and *III* the left-hand wire is positive (+) whereas in *II* and *IV* the left-hand wire is negative (−).

NOTE.—THE EIGHT-POSSIBLE COMBINATIONS OF SWITCH-BLADE POSITIONS AND CIRCUIT-CONNECTIONS PROVIDED BY TWO THREE-WAY

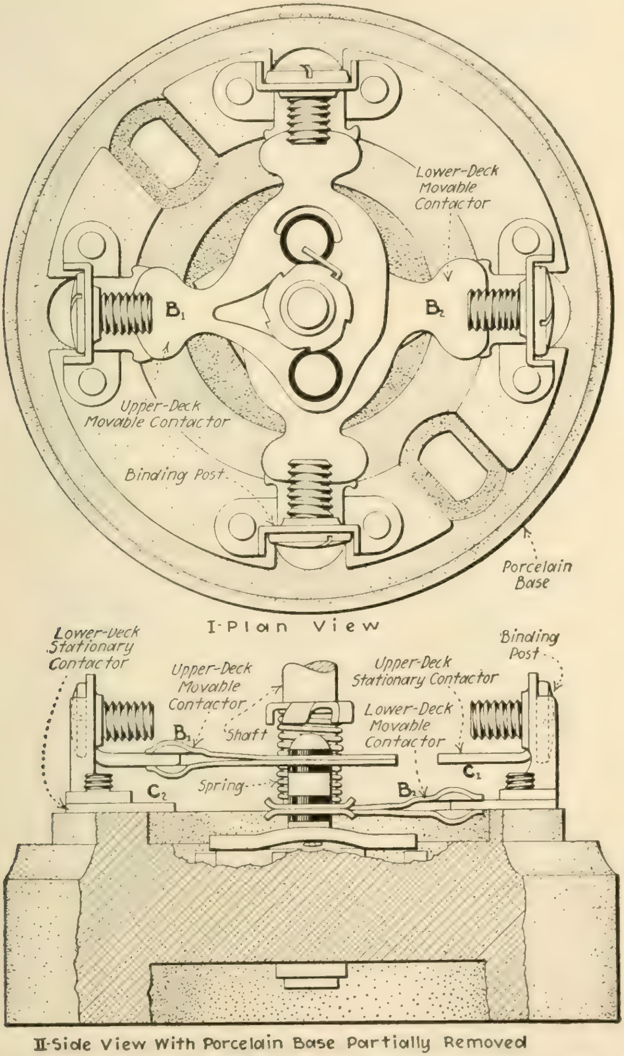


FIG. 119.—Showing construction of four-way, surface snap switch. (*List No.* 2183, *Bryant Electric Co.*)

Switches And One Four-way Switch, Connected For Three-location Lamp-control are shown in Fig. 121. With the switches, A, B, and C, in the positions as shown at I, the lamp is on. By operating either switch A, B, or C, the lamp will be turned off as follows: (1) *Operating A, II results.* (2) *Operating B, V results.* (3) *Operating C, IV results.* Similarly, it can be shown that with any one of the combinations of switch-blade positions which lights the lamp (Fig. 121-*I*, -*III*, -*VI* and -*VIII*), one operation of either A, B, or C will extinguish it; and *vice versa*, if with any combination of positions, the lamp is off (*II*, *IV*, *V*, and *VII*) one operation of either A, B, or C will light it. Thus with any one of the above eight combinations of switch-blade positions, the lamp may be turned either off or on by either switch A, B, or C (see also Div. 5).

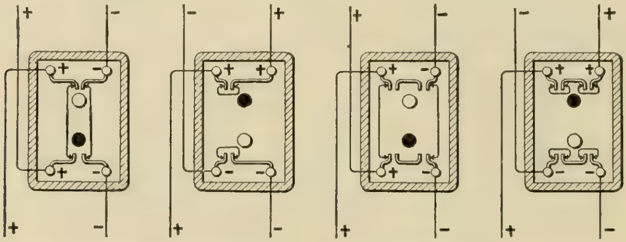


Fig. 120.—Positions of four-way flush switches of the oscillating-blade type.

112. Electrolier Snap Switches Are Made In Both The Single- And Multi-deck Types. Usually, two-circuit electrolier switches have only one deck and three-circuit switches have two or more decks. Practically all electrolier switches are of the revolving-blade type (Sec. 23). A typical two-circuit electrolier switch and the circuit-connections provided thereby, is digrammed in Fig. 122. The switch (Fig. 122) is of single-deck construction, having one T-shaped movable contactor, and three binding-posts. Each binding-post carries one stationary contactor. For complete discussion of electrolier switch circuits see Div. 7.

113. The Construction And Circuit-connections Of Series-parallel Snap Switches are fully described in Div. 7. These switches usually employ a multi-deck arrangement. The movable contactor on each deck may be of either the T-, L-, or I-shape (Fig. 58). The binding-posts carry one stationary

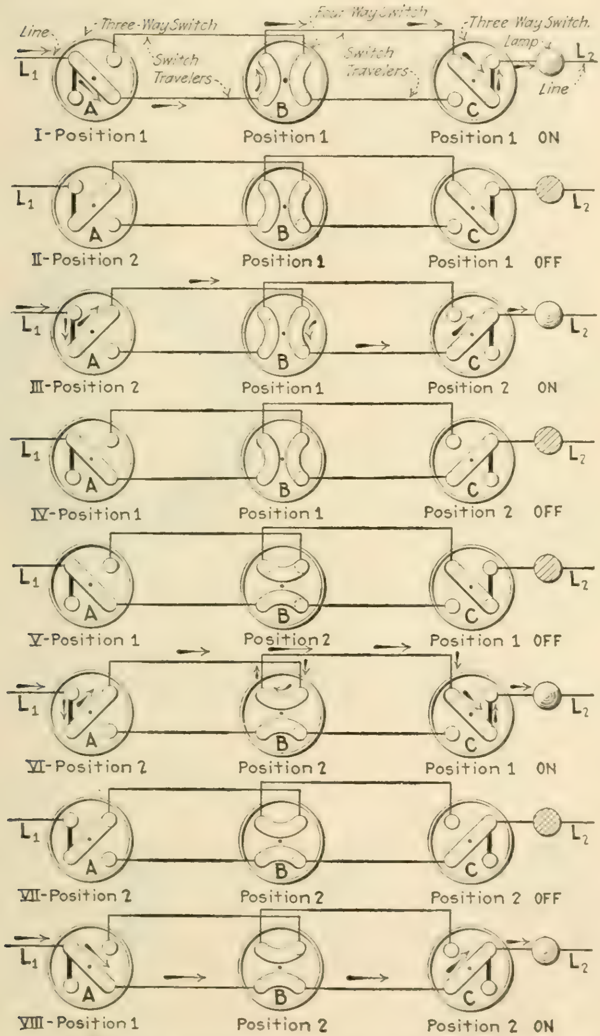


FIG. 121.—Showing the various combinations of switch-positions and the circuit-connections provided thereby for two three-way and one four-way snap switch connected for three location lamp-control. (Arrows indicate current flow.)

contactor or two stationary contactors one above the other. depending upon the desired sequence of circuit-connections.

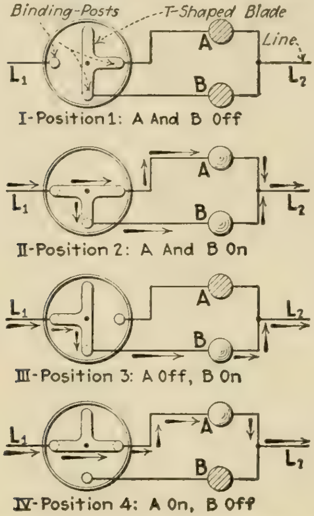


FIG. 122.—Illustrating construction and circuit-connections of a two-circuit electrolier switch.

FIG. 123.—Indicating dial for a rotating-button snap switch. (*Hart Mfg. Co.*)

114. Snap Switches Are Made In Both The Indicating And Non-indicating Types. An *indicating snap switch* is one

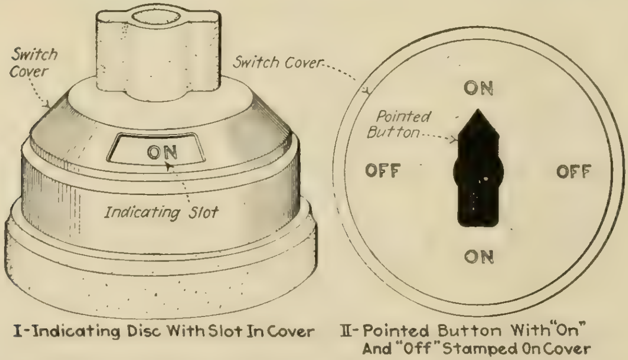


FIG. 124.—Showing various methods of construction of indicating surface snap switches of the rotating-button type.

which, when installed, has some externally-visible marking which indicates whether the switch is open or closed. A *non-*

indicating snap switch has no such marking. One method of construction which is frequently employed in indicating snap switches of the rotating-button type employs an indicating dial, (*I*, Fig. 63) which is fastened to, and rotates with the shaft. It is marked with the words (Fig. 123) "off" and "on" so that when the switch is closed (Fig. 124-*I*) the word "on" is visible through a slot in the switch-cover. When the switch is open, "off" is visible. Another method is shown in Fig. 124-*II*, wherein a pointed button is used. The words "on" and "off" are stamped on the switch-cover, and so arranged that when the switch is closed, the button points to "on." When it is open, the button points to "off" (see also Sec. 308). The on- and off-indications for a two-button push switch are usually provided by making the buttons of different colors, so that, say, when the white button is in, and the black button out, the switch is closed; and when the black button is in, and the white button out, the switch is open.

115. Snap Switches Which Bear The Approval-label Of The Underwriters' Laboratories have been inspected and have been found to comply with certain specifications, regarding both construction and operation, which have been formulated by the laboratories. These specifications are contained in detail in STANDARD FOR SNAP SWITCHES, a copy of which may be obtained from the Underwriters' Laboratories, 207 E. Ohio St., Chicago, Ill.; its cost is approximately $1.00. A brief outline of the operating requirements is contained in the following section.

116. The Underwriters' Laboratories Tests Of Snap Switch Operation consist of: (1) *Overload test.* (2) *Heating test.* (3) *Endurance test.* Each of these tests are briefly described in the notes below. For complete details of the specifications for these tests, see STANDARD FOR SNAP SWITCHES.

NOTE.—FOR A SNAP SWITCH TO COMPLY WITH THE UNDERWRITERS' LABORATORIES OVERLOAD TEST, the switch must—if it has a rating of 10 amp. or less—operate successfully when tested with direct current at 150 per cent. of the rated ampere capacity at full rated voltage. For switches which have a rating in excess of 10 amp., this test is made at 125 per cent. instead of at 150 per cent. of the rated current-carrying capacity. To "operate successfully" the switch must open repeatedly, and without appreciable damage, the overloads just specified.

Note.—For A Snap Switch To Comply With The Underwriters' Laboratories Heating Test, the temperature of the switch-jaws, blades, and other current-carrying parts must not, when carrying continuously the rated current, rise over 54 deg. Fahr. (30 deg. Cent.) above the temperature of the room in which the test is being conducted. The temperature-rise is determined by applying the bulb of a mercury thermometer to the current-carrying parts, and protecting the bulb from air currents by putty or other suitable means.

Note.—For A Snap Switch To Comply With The Requirements Of The Underwriters' Laboratories Endurance Test, it must, when

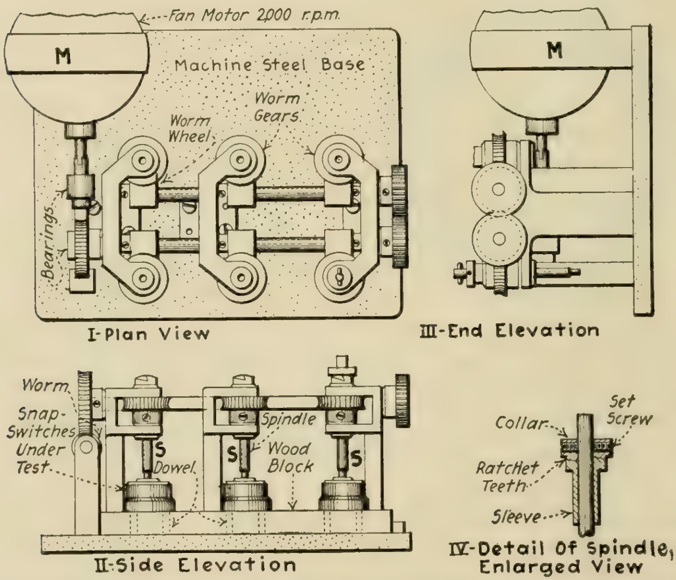


Fig. 125.—Machine for testing snap switches. (The switches which are under test are not shown in *I* and *III*.)

slowly operated at a rate not to exceed 20 snaps per min. while carrying rated current at rated voltage, complete 12,000 snaps before failing. This endurance test is made with a power-driven test machine. The exact form of the endurance-test machine is not specified. The construction and operation of a machine which has been found suitable for this purpose is explained below.

Explanation.—A Snap Switch Endurance-test Machine, designed for testing switches of the revolving-blade type is shown in Fig. 125. The switches to be tested are mounted on the machine as shown at *II*. A non-inductive electric load, consisting of a group of incandescent lamps, is fed through each switch in series. The electric load on each switch is

so adjusted that it is equal to rated current at the rated voltage of the switch. Then, when the driving mechanism operates, the switches are thereby opened and closed. The device is driven by a 2,000-r.p.m. fan motor, M. The whole mechanism is so back-geared that the spindles, S, which turn the switch-mechanism, rotate at about 4 r.p.m.

Each switch is driven through the spindle, S, which is illustrated in detail in *IV*. There are two ratchet teeth on the end of the sleeve, which is held securely in the worm gear. When it is desired to remove any switch from the device or to discontinue the test, the collar may be raised with the fingers This raises the driving shaft so that then the switch will no longer be rotated by the machine. Furthermore, this ratchet clutch permits the switch spring to operate the switch with a "snap," and also permits the action of any "back-lash" which the switch may have.

To prevent the porcelain switch bases from turning on the wrought iron base of the machine a block of wood is inserted under the base, as suggested in the picture. From this block of wood, wooden dowels extend up into the screw holes in the switch base.

QUESTIONS ON DIVISION 2

1. Make a sketch of a knife switch and name the various parts.

2. Under what two headings may the materials used in knife-switch construction be classified?

3. What is the allowable current-carrying capacity per square inch of cross-sectional area for knife-switch blades?

4. Describe knife-switch jaw construction.

5. Describe a method of obtaining firm contact between blade and jaws of a knife switch.

6. What requirement must be met in fastening the jaws to the base? Give two methods of complying with this requirement.

7. By what means are the wires connected to *front-connected* knife switches? To *back-connected* knife switches? What is the point of connection sometimes called?

8. When must *connecting-lugs* be used?

9. Name the different materials which are usually employed in the construction of the following knife-switch parts: (*a*) *Base*. (*b*) *Cross-bar*. (*c*) *Handle*.

10. Classify knife switches according to form.

11. What troubles frequently occur in knife switches? How may they be located and remedied?

12. Under what three headings may snap-switch mechanisms be classified?

13. Give the names of the current-carrying parts of a snap switch.

14. Name the principal types of the contactor mechanisms of snap switches and describe each.

15. Why are metal covers of snap switches lined with an insulating material?

16. Describe the basic principle of snap-switch operating-mechanism.

17. Explain the operation of one type of rotating-button snap-switch mechanism.

18. How may push-button snap switches be classified?

19. Explain the operation of the mechanism of a one-button, push snap switch.

20. Explain the operation of a *release-catch mechanism* in a two-button push switch. Make a sketch.

21. Explain the operation of a *lever-mechanism* for a two-button, push switch. Make a sketch.

22. Make a sketch showing two different button arrangements which are employed in two-button, push-switch construction.

23. Explain the operation of a momentary-contact switch.

24. Name five forms in which snap switches are manufactured and give the general uses for which each form is applicable.

25. Draw the wiring diagrams for the following snap switches, both for the surface and flush types: (*a*) *Single-pole.* (*b*) *Double-pole.* (*c*) *Three-pole.* (*d*) *Two three-way switches for two-location lamp-control.* (*e*) *Two three-way switches and one four-way switch for three-location lamp-control.* (*f*) *A two-circuit electrolier switch.* (*g*) *A three-circuit electrolier switch.*

26. Classify snap switches according to circuit-connections.

27. What is meant by the term *double-deck* as applied to snap-switches? Make a sketch to illustrate. Multi-deck? Draw sketch.

28. Show by sketch the internal circuit-connections and typical construction of each of the following types of switches: (*a*) *Single-pole.* (*b*) *Double-pole.* (*c*) *Three-pole.* (*d*) *Three-way.* (*e*) *Four-way.* (*f*) *Two-circuit electrolier.*

29. What device is used in snap switches which are to be used on highly-inductive circuits? Why?

30. Show by sketch all of the possible combinations of switch-blade positions of two three-way switches connected for two-location lamp-control, and the current-path for each combination.

31. Same as Ques. 30 for two three-way switches and one four-way switch connected for three-location lamp-control.

32. What is an *indicating snap switch?* A *non-indicating?*

33. Explain the indicating devices which are frequently employed in indicating snap-switch construction, for both the rotating- and push-button types.

34. With what three operation tests must *approved* snap switches comply? Explain briefly the requirements of each test.

DIVISION 3

UNDERWRITERS' REQUIREMENTS

117. Compliance With The Regulations Of The National Board Of Fire Underwriters For Electric Wiring And Apparatus Is Usually Necessary if the building is to be insured against fire-loss. These regulations are known as the NATIONAL ELECTRICAL CODE (hereinafter abbreviated to CODE). The CODE has no legal force except in those municipalities where it has been legalized by statute. Many cities have regulations, that are based upon and are similar to the CODE, which have been legalized by statute or ordinance, and which, in those cities, must be observed.

118. The Code Requirements Which Are Treated Herein are only such as relate to the installation of switches, circuit-wires, and fuses for low-potential (600 volts or less) building-lighting circuits. Since practically all electrical devices which are on the market are *approved* by the Underwriters' Laboratories as regards design and material, it is ordinarily necessary for the installer to watch only the installation requirements of the CODE. The following sections contain the more important CODE (1920 *Edition*) requirements and recommendations which relate to interior switch and lighting-circuit installation.

NOTE.—CERTAIN 1923-CODE RULES WILL PROBABLY BE DIFFERENT FROM THE CORRESPONDING 1920-CODE RULES. As this book goes to press (February, 1923), there is being circulated a bulletin which contains a number of proposed changes in the rules of the 1920 Edition of the NATIONAL ELECTRICAL CODE. This bulletin was prepared by the *Electrical Committee* of the *National Fire Protection Association* and will be submitted to the *National Board Of Fire Underwriters* at the March 12, 1923 meeting in New York City, for the purpose of having these proposed changes incorporated in the 1923 Edition of the CODE. At this time it is impossible to predict whether or not these proposed changes will be adopted but it appears probable that they will be. Therefore, it

is likely that certain of the 1920-Code rules, which are now in effect and upon which this book is based, will be changed in the 1923 Edition. Attention is directed to some of these possible changes at various places in the book. In any event, one should consult the 1923-Code before proceeding definitely.

Note.—An Approved Device is a device, a sample of which has been examined, tested, and approved for use, by the *Underwriters' Laboratories.* The *Undederwriters' Laboratories* is an institution maintained by the *National Board of Fire Underwriters,* the principal office and testing station of which is located at 207 E. Ohio St., Chicago, Ill. All approved devices and materials are so labeled with metal plates, paper stickers, or tags, which are furnished, to manufacturers of approved equipment, by the *Underwriters' Laboratories.*

119. Approved Knife Switches Are Plainly Marked With The Maximum Ampere And Voltage Rating for which they are designed (Code Rule 65 *a*). This marking (Table 120) must be so located that it can be read when the switch is installed. The voltage and the probable maximum load on the circuit must not exceed the voltage and ampere rating as stamped on the switch. A switch of larger rating than that of the circuit which it controls may, if the circuit is properly fused, (Sec. 169) be used, but it will usually be uneconomical.

120. Table Showing Classification And Markings Of Knife Switches. (Code Rule 65*a*.)

30 to 1,000 amp., inclusive	
Classification	Markings
125 V., D.C. or A.C. Only for switchboards and panelboards. (With or without fuses.)	125 V...Amps.
250 V., D.C. or 500 V., A.C. (Without fuses.)	250 V., D.C., 500 V., A.C. ...Amps.
250 V., D.C. or A.C. (With fuses.)	250 V...Amps.
500 V., A.C. (With 600-volt fuses.)	500 V., A.C. ...Amps.
600 V., D.C. or A.C. (With or without fuses.)	600 V...Amps.

30 to 1,000 amp., inclusive	
Classification	Markings
Triple-pole: With 125-volt spacings between blades. For use on three-wire systems having 125 volts between adjacent wires and not over 250 volts between outside wires.	125 V...Amps.
Triple-pole: With 250-volt spacings between blades. For use on three-wire-systems having 250 volts between adjacent wires and not over 500 volts between outside wires.	250 V...Amps.

Above 1,000 amp.

For switches of capacities above 1,000 amperes, the A.C. rating will generally be less than the D.C. rating, and in such cases the marking should indicate the ampere rating definitely as A.C. or D.C. The frequency in cycles should also be stated.

121. Switch Bases Upon Which Live Parts Are Mounted (Code, Class *D*, *Bases*) must be made of *approved* non-combustible, non-absorptive insulating material, such as hard rubber, slate, marble, porcelain, fiber, etc. The design of the base must be such that it will withstand the most severe conditions which are likely to be encountered in practice.

Note.—Screws For Supporting Bases which have an area greater than 25 sq. in. must be at least four in number. Holes for the supporting-screws must be so located (*A*, Fig. 126) or countersunk (*A* + *B*, Fig. 127) that there will be at least ½-in. space, measured over the surface, between the screw-head or washer and the nearest live metal part. Screws (*S*, Fig. 126) which are located between parts of opposite polarity must be countersunk. Nuts or screw-heads on the under side of the base must be countersunk and sealed with a water-proof compound.

122. The Spacings Between Knife-switch Parts (Code Rule 65*c*) must be equal to or exceed that shown in Table 123. The dimensions as given for break distances (Column 5, Table 123, and *A* Fig. 128) do not apply to quick-break attachments (Sec. 132) on switch mechanisms.

Note.—The Minimum Allowable "Break" Or "Between-parts-of-opposite-polarity" Distance Between Knife-switch Parts

(A and B, Fig. 128, and Table 123) is taken as the shortest distance between any part of the switch-contact mechanism. That is, it is the shortest distance as measured between the metal blocks (contact-blocks) which carry the jaws, between the screw-heads or nuts at the hinge-jaws,

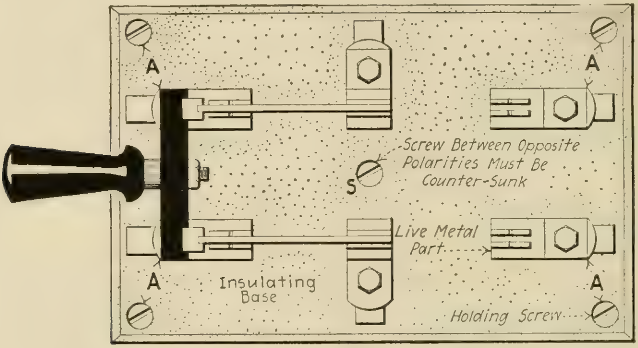


FIG. 126.—Showing CODE requirements for distances between holding-screws and nearest live metal parts for switch bases. (If area of base exceeds 25 sq. in., at least 4 holding screws must be used. Distance A must not be less than ½ in.)

or between the flared edges of switch jaws, depending upon various features of design and construction. Switches are frequently equipped with extensions (E, Fig. 173) for enclosed fuses of either the cartridge or Edison plug types. However, the switch spacings given in Table 123 should not

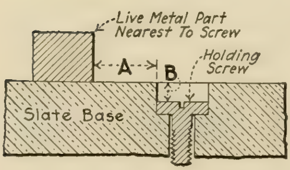


FIG. 127.—Counter-sunk holding-screws for switch bases must be so located that $A + B$ is at least ½ in.

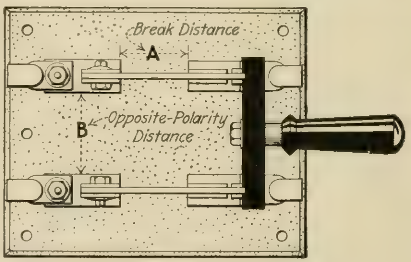


FIG. 128.—Measurements for minimum allowable knife switch spacings.

be applied to cutout bases, even though the cutout base is a part of the switch construction. For the minimum allowable distance between live metal parts of cutouts, the cutout is to be considered as a unit separate and distinct from the switch.

123. Table Showing Minimum Allowable Knife-switch Spacings. Measurements are to be taken within the area of

the switch base bounded by the contact parts of the switch mechanism (see Fig. 128).

Mounting	Maximum voltage	Ampere rating	Min. distance between metal parts of opp. polarity in in. (*B*, Fig. 128)	Min. break distance in in. (*A*, Fig. 128)
Switch-boards and panels only	125 V. D.C. or A.C.	30	1	¾
		60	1¼	1
All other switches	125 V. D.C. or A.C.	30	1¼	1
		60 and 100	1½	1¼
		200 and 300	2¼	2
		400 and 600	2¾	2½
		800 to 6,000	3	2¼
	250 V. D.C. or A.C.	30	1¾	1½
		60 and 100	2¼	2
		200 and 300	2½	2¼
		400 and 600	2¾	2½
		800 to 6,000	3	2¾
	500 V. A.C.	30, 60 and 100	2¼	2
		200 and 300	2½	2¼
		400 and 600	2¾	2⅓
		800 to 6,000	3	2¾
	600 V. D.C. or A.C.	30 and 60	4	3½
		100 to 6,000	4½	4

NOTE.—SWITCHES MARKED "250 V., D.C., OR 500 V., A.C." (CODE Rule 65*d*) must be provided with fuse terminals. Although such a switch alone may be used for either voltage, there is no such interchangeable rating for cutouts. See Tables 161, 164 and 166. That is, there is no approved cutout base which is suitable for both 250 volts, D.C., and 500 volts, A.C.

NOTE.—SWITCHES RATED AT 300 AMP. ARE TO BE USED ONLY ON SWITCHBOARDS. The only standard cutout base (Nos. 5 and 11, Table 161) suitable for use with a switch of this size would be of the 201–400-amp. classification. This would enable the 300-amp. switch to be fused with, say, a 400-amp. fuse which would not provide it with proper

protection. Therefore, at the time knife-switch ratings were standardized and made to correspond with the enclosed-fuse-cutout-base ratings (Table 161) the 300-amp. switch was retained as a special size for use only on switchboards. The 300-amp. switch was thus retained with the understanding on the part of the switch manufacturers that a 300-amp. switch would not be supplied by them as a stock article for general use on individual bases.

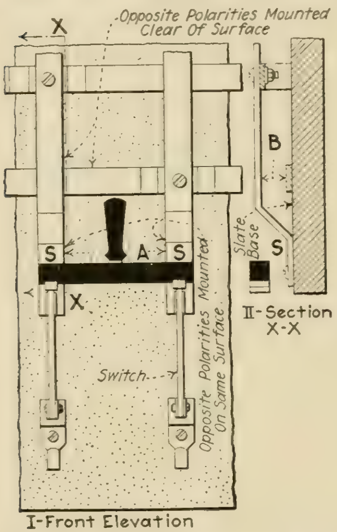


Fig. 129.—Part of panel-board showing parts of opposite polarity outside of the area bounded by the switch mechanism "mounted on same surface" and "mounted clear of surface."

124. Minimum Allowable Spacings Between Parts Of Opposite Polarity which are outside the area bounded by the switch mechanism (Code Rule 65*c*) are given in Table 125. This table of dimensions applies to busbars and enclosed fuses of either the cartridge or Edison-plug type, but it does not apply to open link fuses (Sec. 153). In panel-board construction, the busbars are mounted on either *the same surface* (*S*, Fig. 129), or one busbar is mounted over another (*B*, Fig. 129) *clear of the surface.* Distance given in Columns 2 and 3, Table 125, are illustrated by *A* and *B*, Fig. 129.

125. Table Showing Minimum Allowable Distances Between Parts Of Opposite Polarity Which Are Outside Of The Area Bounded By The Switch Mechanism. (Code Rule 65*c*.)

Voltage	(*A*, Fig. 129) When mounted on same surface, in.	(*B*, Fig. 129) When clear of surface, in.
Not over 125 V.	¾	½
Not over 250 V.	1¼	¾
Not over 600 V.	2	1¾

126. The Contact-block Which Carries The Break- And Hinge-jaws must be (CODE Rule 65*b*) secured to the base or mounting surface in such a manner as to prevent possible turning of the jaws. Manufacturers usually meet this requirement by using dowel-pins, or screws as shown in Fig. 130.

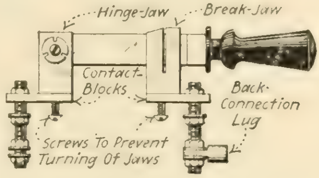


FIG. 130.—Showing method of preventing knife-switch jaws from turning.

127. The Cross-bar Must Be Secured To Each Blade in such a manner as to prevent turning and twisting. This is usually accomplished by screws, dowel-pins, or a shoulder on the blade which fits snugly into a recess in the cross-bar.

NOTE.—IN OPERATING A KNIFE SWITCH, FIRM CONTACT MUST BE QUICKLY MADE BETWEEN THE BLADES AND THE JAWS or severe arcing will result. This is not only injurious to the switch but greatly increases the fire hazard. Thus, if the jaws become turned, or if the union between the cross-bar and blades becomes loose, a heavy arc may be drawn when an attempt is made to close the switch.

128. Switches Which Are Rated Above 400 Amp. At 600 Volts, Or 600 Amp. At 250 Volts exceed the capacity of *approved* cartridge enclosed fuses (Table 164). Such switches may be fused by arranging the fuses in multiple (CODE Rule 65*d*) provided that: (1) *As few fuses as possible are used.* (2) *The fuses are of equal capacity.* (3) *The multiple-arranged terminals for each pole are mounted in common* as shown in Fig. 131.

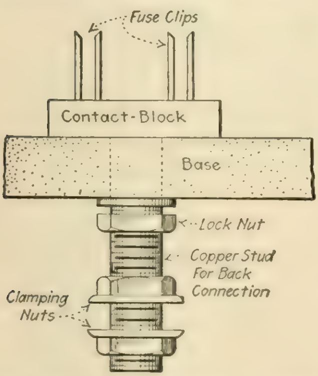


FIG. 131.—Fuse terminals mounted in common. See also Fig. 535.

EXAMPLE.—If it is desired to arrange multiple-fuse terminals for a two-pole knife switch which is rated at 800 amp., 250 volts, *two 400-amp., 250-volt fuses would be required for each pole* (see Fig. 535). Although four 200-amp. fuses, or one 600-amp. fuse and one 200-amp. fuse in each pole, would have ample capacity for the switch, neither of these latter combinations would comply with CODE Rule 65*d*.

129. A Switch Barrier (*R*, Fig. 132) is a block of insulating material which is placed between knife-switch jaws of opposite polarity. Barriers which are to be placed between the hinge-jaws (Fig. 132-*I*) must (Code Rule 65*f*) be of non-absorptive insulating material, and those which are to be placed between the break-jaws (Fig. 132-*III*) must be of a non-combustible, non-absorptive insulating material. The usual construction consists of a block or plate of non-combustible non-absorptive insulating material extending from a point, P_1, outside of the area bounded by and between the break-jaws to a point, P_2, similarly located with reference to the hinge-jaws as shown in Fig. 132-*II*.

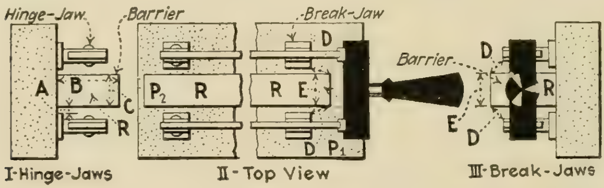


Fig. 132.—Barrier used to decrease space normally occupied by switch.

130. Barriers Are Used To Decrease The Base-areas Required For Switches. That is, if a properly-designed barrier is mounted on a switch, then the switch blades of opposite polarity may be set closer together than if a barrier is not used. Barriers that are designed to be placed between hinge-jaws must (Code Rule 65*f*) be of such a size and so located as to provide a separation between contact parts of opposite polarity (as measured along the shortest insulating-surface path over or around the barrier) which is equal to that required (Table 123) for switches without barriers. Furthermore, the barriers must be so located as to provide a separation between other current-carrying parts equal to that specified in Table 125. Barriers that are designed to be placed between the break-jaws (Fig. 132-*III*) must (Code Rule 65*f*) be of such a size and so located as to provide a separation between contact parts of opposite polarity (as measured in the shortest path through air, over or around the barrier) which is equal to that required (Table 123) for switches without barriers.

EXPLANATION.—WHEN BARRIERS ARE USED ON SWITCHES between the hinge-jaws, it is, since no arc is produced at this point on opening and closing the switch, only necessary to provide sufficient insulation between the jaws to prevent "creeping" along the surface of the switch-base and barrier. That is, the distance, $2A + 2B + C$ (Fig. 132), must at least, be equal to that given in Column 4, Table 123.

When a current is suddenly broken, a back- or counter-electromotive force of self-induction is thereby produced. The voltage of this counter-e.m.f. is generally much greater than the normal voltage of the circuit. Thus, when a knife switch is operated to open a circuit, the voltage between the break-jaws of opposite polarity may be many times the voltage-rating of the switch. This high voltage will, if the dielectric (air path) between the break-jaws is broken down, cause a vicious arc to be established between the jaws. This arc, if once formed, may continue until the switch is entirely isolated from the source of voltage. Therefore, the path which has the lowest dielectric strength (the shortest air path, as $2D + E$, Fig. 132) must at least be equal to the distance given in Column 4, Table 123.

131. Sufficient Spacing For Multi-pole, Double-throw, Front-connected Knife Switches May Be Obtained By The

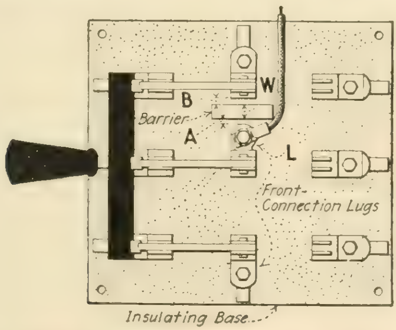


FIG. 133.—Showing method of obtaining required space between live metal parts of a multi-pole front-connected switch according to CODE rule 65*g*.

Use Of Barriers, as shown in Fig. 133. In switches of this type front connection-lugs, *L*, are necessary on the inside jaws. Since these lugs extend out from the jaw, they reduce the horizontal clearance between jaws. The CODE, Rule 65*g*, specifies that such switches must have standard switch spacings (Table 123) between live metal parts, or such spacing must be obtained by the use of barriers, as explained for hinge-jaw barriers in Sec. 130. That is, if the barrier is of a

height, H, then (Fig. 133), the distance, $A + 2H + W + B$, must at least be equal to the distance specified in Column 4, Table 123.

132. Auxiliary Contacts Of A Renewable Or Quick-break Type Must Be Provided On All 600-volt Knife Switches Which Have A Current-rating Of 200 Amp. Or Above, (Fig. 134, and CODE, Rule 65*e*). The CODE does not require, but it does recommend that a switch of this type be used for breaking direct-current circuits of over 250 volts.

EXPLANATION.—As the switch blade (B, Fig. 134) is opened, the auxiliary blade, A, is at first retained by friction between the break-jaws, J. Meanwhile, as B is moved upward, the tension of the spring, S, is increased. Finally, as B is opened still further, the tension of S becomes sufficient that it overcomes the friction between A and the break-jaws. Then A is abruptly pulled or "snapped" from the jaws by S. This *quick-break* tends to prevent arcing because, under normal conditions, the arc does not, probably, have time to form. Thus, the auxiliary quick-break attachment renders it impossible to draw a dangerous arc by opening the switch slowly if the switch is used on a circuit within its rating.

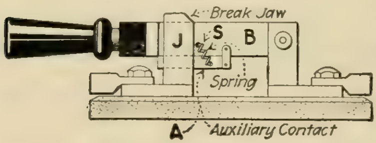


FIG. 134.—Quick-break switch required for ratings greater than 600-v., 200-amp.

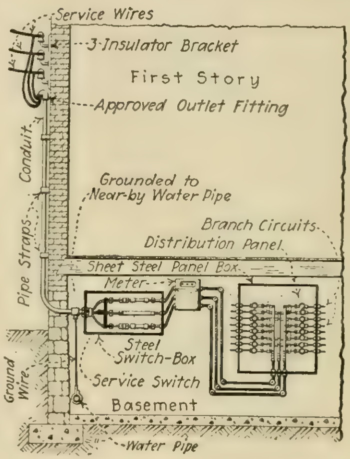


FIG. 135.—Typical three-wire basement service-entrance showing fuses in ungrounded wires. (Distribution panel is in basement in this installation.)

133. Switches Must Be Placed On All Service Wires (CODE Rule 24*a*), whether overhead or underground, in the nearest readily-accessible place to the point where the service wires (Fig. 135) enter the building. Such a switch is called a *service switch.*

NOTE.—YARD-WIRES RUNNING FROM BUILDING TO BUILDING IN PRIVATE PLANTS are not considered as services (see Sec. 10). Switches

are not, therefore, required at the point where the conductors enter the buildings (Code Rule 24*a*), provided other switches are located on the mains or if the generators are nearby.

134. The Connections To The Service Switch Must Ordinarily Be So Arranged That When It Is Open The Current Will Be Cut Off From All Circuits And Devices Within The Building (Fig. 136). An exception is; that when the service switch, the service fuses, and the meter, are combined in an *approved* device, or a combination of such *approved* devices (Figs. 137, 138, and 139) which have no exposed wiring or live parts, then the switch may be so arranged that it does not

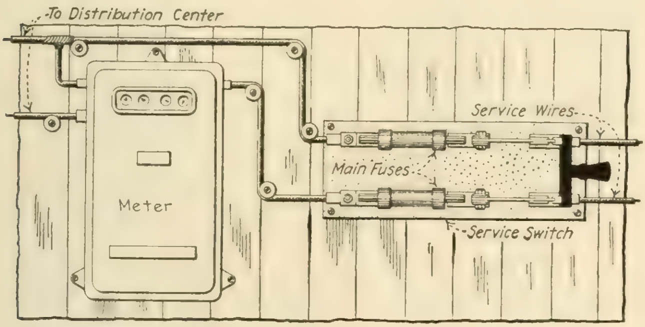


Fig. 136.—Service switch so wired that all circuits and devices within the building may be disconnected by opening the switch. (Most watt-hour meters are designed to feed "from left to right," which means that the wires from the source of voltage enter the left-hand side of the meter and leave at the right. The meter above illustrated feeds from "right to left." In cities where 'left-to-right" feed meters are used, the local inspection departments ordinarily require that the energy-supply wiring to the meter approach the meter from the left.)

disconnect the fuses or the meter from the line. The *approved device* is a metal enclosure, constructed and proportioned in accordance with Underwriters' requirements, which encloses all live parts.

135. Service Switches Must Be Enclosed In Metal Boxes (Code Rule 24*a*), except when used in connection with such *approved* devices as are specified in Sec. 134, or except when mounted on switchboards. The service switch is frequently installed (Fig. 137) on the panel-board within a service cabinet.

This method of installation is not in accordance with the Code recommendation (not a requirement) that the service switch

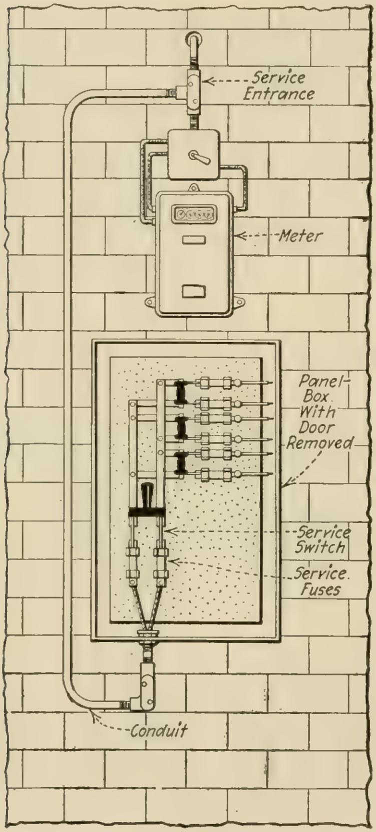


Fig. 137.

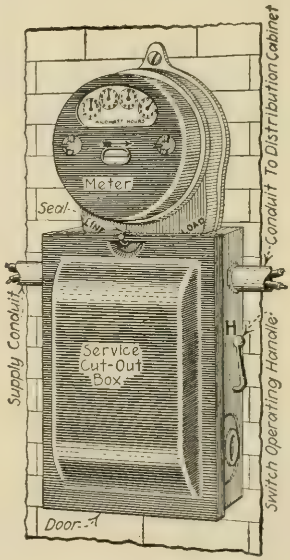


Fig. 138.

Fig. 137.—Combination of approved devices wherein service switch may be so wired that meter and service fuses are not disconnected by opening service switch. Note that the National Electrical Code specifies that all service conduits must be permanently grounded unless insulated from the ground. Since the above service conduit is carried on a brick wall, it can scarcely be considered as being insulated. It should therefore, probably, be grounded.

Fig. 138.—Compact combination of "approved devices." (*Trumbull Electric Mfg. Co.* Service switch and fuses are in the cut-out box under the seal of the lighting company, switch is externally operated by means of handle, *H*.)

be of a type (Fig. 140) which may be operated without exposing the operator to accidental contact with any live parts.

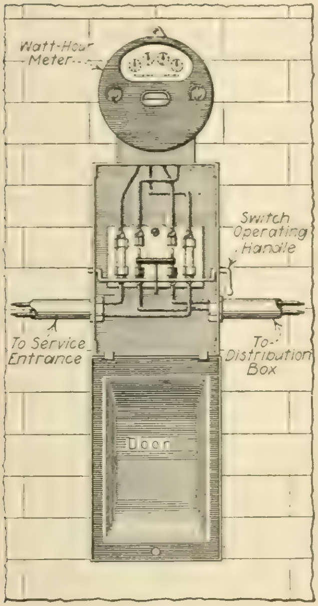


FIG. 139.

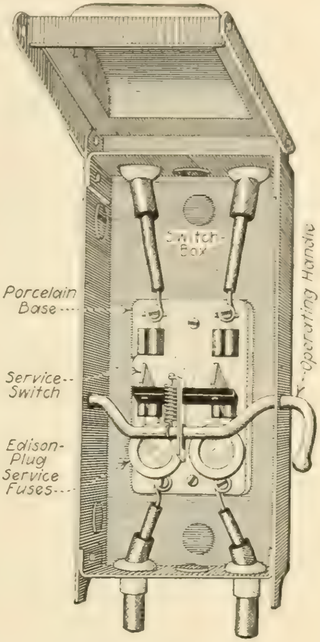


FIG. 140.

FIG. 139.—*Trumbull Electric Company* meter service switch and box—door open.

FIG. 140.—Enclosed externally-operated service switch. (The words "On" and "Off" are stamped in proper positions in the side of the sheet metal box opposite the extreme positions of the operating handle.)

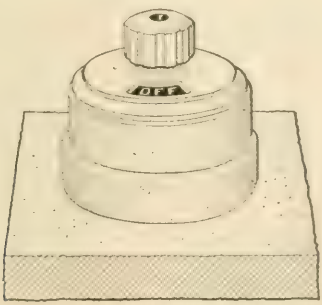


FIG. 141.—An indicating surface switch. (When the switch is open, "off" is visible through the slot. When closed, "on" is visible. All exposed parts of the switch shown are of porcelain.)

136. Service Switches Must Plainly Indicate Whether They Are Open Or Closed (CODE Rule 24*a*). If the switch is of the knife-switch type (Fig. 137) not externally operated, no further provision for indication is necessary; the position of the switch blades shows whether it is open or closed. However, if the switch is of the externally-operated type (Fig. 140), or of the "snap" type (Fig. 141), the words "on" and "off" must be shown and be so located as to plainly indicate whether the switch is open or closed.

137. Service Switches Must Disconnect All Ungrounded Wires Of The Circuit (CODE Rule 24*a*). A disconnecting-strap may be employed in lieu of a switch blade for grounded conductors. With three-wire, single-phase, alternating-current systems, which have a grounded neutral, or three-wire direct-current systems, the service switch may be so designed (Fig. 142) as to permit either outside wire to be opened independently of the other, but the design must be such that the neutral cannot be opened without opening both out side wires (see Sec. 206).

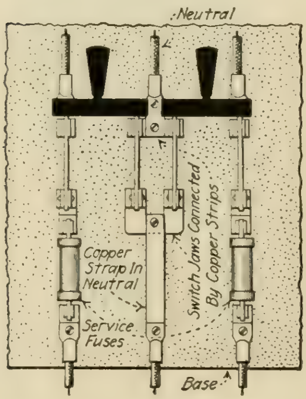


FIG. 142.—Service switches on three-wire grounded-neutral system so arranged that neutral cannot be opened without opening both outside wires.

138. Switches Must Always Be Placed In Accessible Places And Must Always Be Grouped Insofar As Possible (CODE Rule 24*b*). In the event of a short circuit causing a fire, the faulty circuit may be more quickly disconnected if all switches are located in one group than if they are scattered throughout a building. Furthermore, concentrating the switches at a certain location facilitates rapid testing.

NOTE.—SERVICE SWITCHES SHOULD NOT BE PLACED BEHIND OBSTRUCTIONS such as shelving, cabinets, or the like. They should also be mounted at a height of not more than about 5½ ft. from the floor.

139. Switches Must Be Installed, When Possible, In Dry Places (CODE Rule 24*b*). However, if it is necessary that they be placed in damp places such as basements and similar

locations, they must (CODE Rule 19*c*) be mounted in *approved* boxes or cabinets. When located in wet places, or outside of buildings, they must be mounted in *approved weather-proof* boxes or cabinets. The metal parts of a switch which is located in a damp place will usually corrode. The current-carrying parts may thereby be so affected that the switch will not function properly in closing the circuit. Or it may corrode so badly that it cannot be opened readily. Switches installed in damp places are also more susceptible to internal short-circuits than when installed in a dry place.

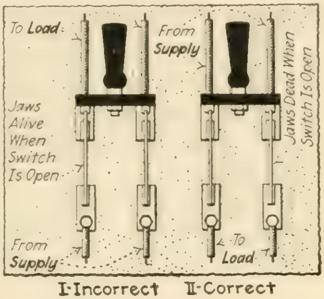


FIG. 143.—Correct and incorrect method of wiring a single-throw knife switch.

140. Knife Switches Should Be So Wired (CODE Rule 24*b*) that: (1) *The blades will, when possible, be dead* (Fig. 143-*II*) *when the switch is open.* (2) *Gravity will not tend to close them.* Accidental contact or short circuit which might be produced by the human body or by a screw-driver is not so likely to occur if the blades are dead (Fig. 143-*II*) and the break-jaws alive, as if the blades are alive (Fig. 143-*I*) and the break-jaws

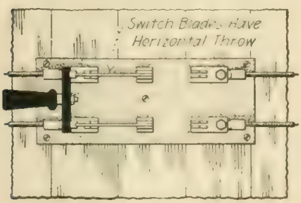


FIG. 144.—Double-throw switch so mounted that the throw is horizontal.

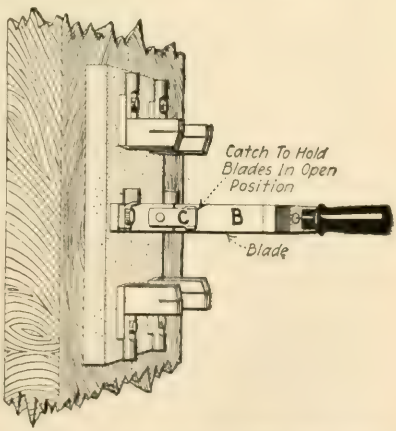


FIG. 145.—Double-throw switch, so mounted that throw is vertical. (It is provided with catch, *C*, which engages in a depression in *B*, to hold blades in open position. This prevents the blades being closed by gravity.)

dead. The Code requires that all single-throw knife switches be mounted so that gravity will not (Fig. 143) tend to close them. A double-throw knife switch may be mounted so that the throw will be horizontal (Fig. 144), or vertical, but if the throw is vertical a locking device (Fig. 145), which is so constructed as to securely hold the blades in the open position when they are so set must be provided.

141. Single-pole Switches Must Not Be Used As Service Switches (Code Rule 24*c*). A single-pole switch, when open, does not effect complete isolation of the circuit which it controls. If, in a two-wire ungrounded lighting system, a single-pole switch (Fig. 146) was used as a service switch,

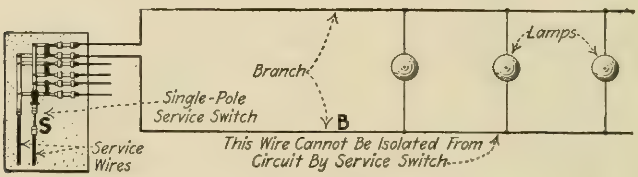


Fig. 146.—Single-pole switch should not be used as a service switch.

there would be no direct means of disconnecting wire *B* from the source of voltage. Consequently a workman might, while making repairs to the line, be severely injured. Also, if *B* came in contact with a water-pipe, or otherwise became grounded, sufficient current might flow to eventually cause a fire, and yet not rupture the fuse. The current-flow could not, in this case, be stopped by opening the single-pole service switch, *S*.

Note.—Single-pole Switches Should Not Be Used To Control Circuits Which Are Located In Damp Places (Code Rule 24*c*). A circuit which is located outside of a building or in a damp place is more likely to become grounded than is one which is otherwise located. Therefore, the controlling-switch for such a circuit should provide a means of complete isolation of the entire circuit. The average basement is not usually considered a damp place and therefore would not ordinarily require a double-pole switch. Rooms in which much washing is done, rooms in which there is steam, dye rooms and sometimes garages may be considered as damp places. When in doubt, consult the Electrical Inspection Department which has jurisdiction.

142. Single-pole Switches Must Never Be Placed In The Neutral Wire Of A Three-wire System (CODE Rule 24*c*) except in a two-wire branch (Fig. 147) or tap circuit supplying not more than 660 watts. (See Sec. 171 for results of open neutral.) The neutral wire of practically all three-wire

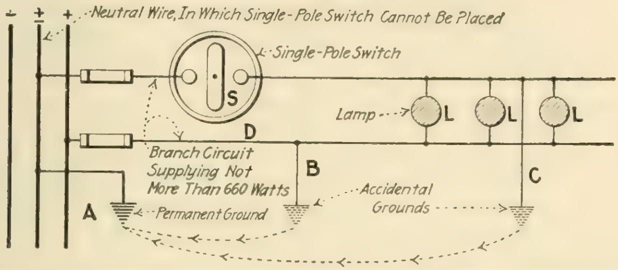


FIG. 147.—Undesirable arrangement showing conditions which may occur when a single-pole switch is installed in that side of the branch circuit which is connected to the neutral of a three-wire system.

lighting systems is permanently grounded, usually outside the building. Therefore, if the switch is placed in that side of the branch which connects to the neutral, as shown in Fig. 147, and an accidental ground should occur, as at *C*, the current will flow through *D*, *L*, *C*, and along the path through the

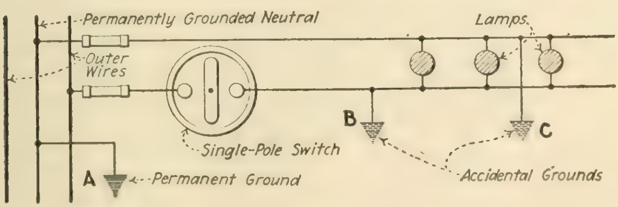


FIG. 148.—Preferable arrangement. Single-pole switch, when connected into that side of the branch which connects to the outer wire of a three-wire system, can be used to isolate an accidental ground.

ground as shown by the dotted arrows, to *A*, thus rendering it impossible to extinguish the lights by opening the switch, *S*. If the other side of the branch should accidentally become grounded as at *B*, a short-circuit current, which may be extremely dangerous and difficult to locate, will flow through *DBA*. If, however, (Fig. 148) the single-pole switch is

installed in that side of the branch which connects to the outer wire, neither of the conditions illustrated in Fig. 147 can occur.

Note.—The Reason Why Double-pole Switches Are Usually Provided On The Branch Circuits In Panel-boxes And At Distribution Centers is not on account of any Code rule, but because the double-pole switch, when open, completely isolates the branch circuit from the mains. Although a single-pole switch installed in the "hot" wire (Fig. 148) of a two-wire branch from a three-wire-grounded-neutral system, will, when open, render the circuit "dead," most manufacturers prefer to equip their panel boards with double-pole switches in the branch circuits for the following reasons: (1) *There are many systems wherein the neutral is not grounded, and the manufacturer may not know beforehand for what kind of a system the panel board will be used. Therefore, panel boards are practically always supplied with double-pole switches in the branch circuits so that they may be adapted to any system.* (2) *Equipping all panel boards with the same type of switch minimizes the number of switches and parts which must be carried in stock.* There are however a number of installations with single-pole switches in the branch circuits, a number of which may be found in New York City, which were engineered by *J. Bassett Jones.*

143. Single-pole Switches Are Not Generally Used On Any Circuits Supplying More Than 660 Watts. Although the use of single-pole switches is not specifically prohibited by the Code, except as outlined in Sec. 142, and practical considerations usually render it unwise to employ single-pole switches for controlling circuits, the wattage of which exceeds 660. Many wiring inspectors will not permit the use of single-pole switches for controlling circuits of capacities exceeding 660 watts. The double-pole switch always has the advantage that, when opened, it cuts both legs of the controlled circuit "dead." It thereby minimizes the possibility of difficulty due to shock by accidental contact or by fire.

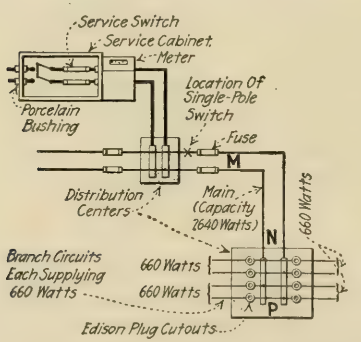


Fig. 149.—Showing how a single-pole switch might be installed at X for the control of a circuit MN of a wattage exceeding 660.

Example.—There is nothing in the Code to prohibit the installation of a single-pole switch, of proper capacity, at X in Fig. 149. A switch thus placed at X would, when opened, "turn off" all the lights feeding from panel P. But it might not, when open, render "dead" both sides of the circuit beyond it. Hence, the use of single-pole switches for applications such as that of Fig. 149 should be discouraged.

144. Three-way Switches Are Considered As Single-pole Switches (Code Rule 24*c*). Four-way switches, and those types of electrolier and series-parallel switches which do not disconnect both wires from the source of supply, are also considered as single-pole switches, and the rules of Secs. 141, and 142 relating to single-pole switches likewise apply to these types just mentioned (see Sec. 251).

145. Flush Switches Or Receptacles Must Always Be Enclosed In An Approved Iron Or Steel Box, except as noted below. This metal box (Fig. 150) must be used in addition

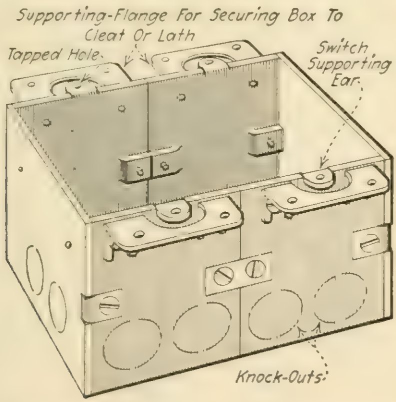


Fig. 150.—Metallic flush switch-box for a two-gang installation.

to the porcelain enclosure which forms a part of the switch or receptacle. This rule is intended to protect the switch against mechanical injury and to minimize the possibility of a fire being started inside the wall, in which the switch is installed, due to injury to the switch, or to arcing in the switch.

Note.—Receptacles And Attachment Plugs At Floor Outlets Must Be Enclosed In Floor-outlet Boxes (Code Rule 24*d*) which have been especially designed and *approved* (Fig. 151) for this purpose.

However, where such devices are so located that they are not subject to mechanical injury or dampness, departure from this rule may be allowed, but permission for such departure must be obtained in writing from the inspection bureau having jurisdiction.

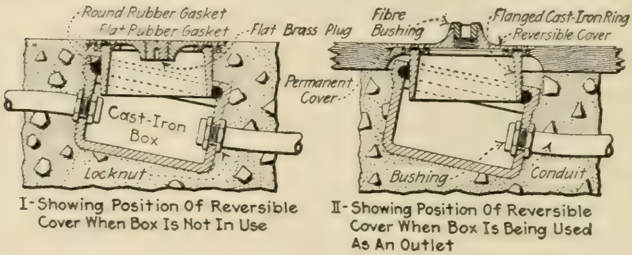


Fig. 151.—An approved adjustable floor outlet box. (*Frank Adam Electric Co.*)

146. Flush-switch Boxes Must, When Possible, Be Supported By 7/8-in. Blocks (Figs. 152 and 153). The blocks must, in new-building work, be fastened between the studs, flush with the back of the lath (Code Rule 24*e*). The switch-box is then usually adjusted on the supporting flanges (Fig. 150) so that the front of the box (Fig. 152-*II*) will project outward

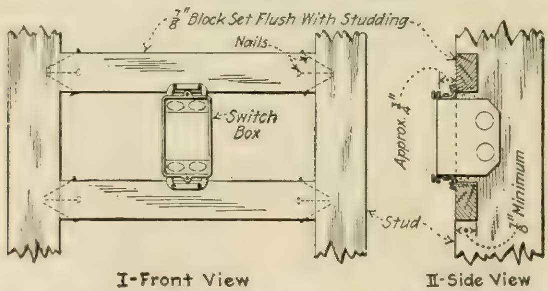


Fig. 152.—Flush switch box installed in new building ready for wiring.

about 3/4 in. from the face of the studding, thus making the front edge of the box approximately 3/8 in. from the outer surface of the laths. Since the plaster is usually about 7/8 in. thick (measured from the face of the studding) the front of the switch-box will then lack about 1/8 in. (Fig. 153) of being flush with the outer surface of the plaster. This permits the switch-supporting screws to be left in the box while the plastering is

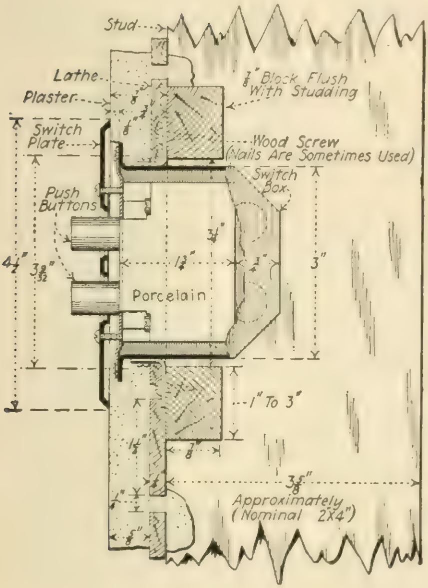


FIG. 153.

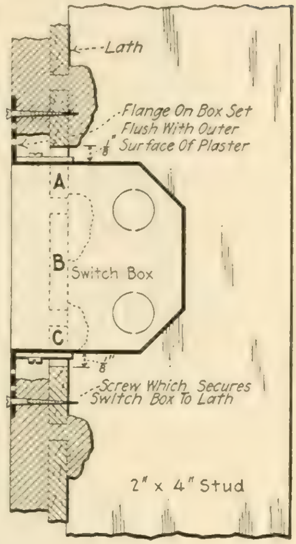


FIG. 154.

FIG. 153.—Installation of flush switch in new building.

FIG. 154.—Installation of flush switch box in plastered partition wall of finished building. (All of lath *B*, and approximately one half of each of laths *A* and *C* are cut away to admit box. This leaves about one half of each of laths *A* and *C*, to which the box is secured by screws.)

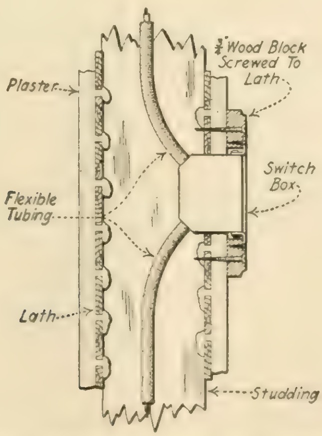


FIG 155.—Flush switch-box installed on surface base block in a finished building.

being done. Thereby, their tapped holes are prevented from filling with plaster.

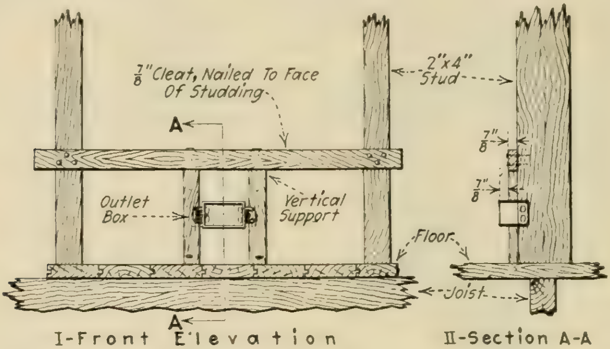


Fig. 156.—Installation of steel outlet box for baseboard outlet.

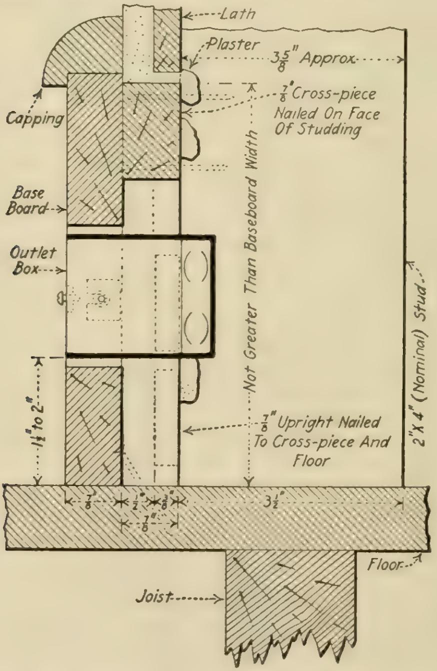


Fig. 157.—Metal box installed for baseboard outlet.

When cleats back of the lath cannot be provided, as in wiring a finished building, the switch-box may be held to the

lath (Fig. 154) by screws through the supporting flanges. There is a question as to whether the construction of Fig. 154 is in strict conformance with Code Rule 24*e*; but it is a fact that most wiring inspectors will approve this construction for finished-building wiring. Or if adequate support cannot be thus provided, it may be fastened to wooden base-blocks (Fig. 155) of not less than 3/4 in. in thickness, mounted on the face of the wall, which must in turn be securely fastened to the lathing with screws. A typical baseboard-outlet installation is illustrated in Figs. 156 and 157.

147. Snap Switches Are Recommended For The Control Of Lighting Circuits which do not carry more than 30 amp. or which do not have a voltage exceeding 250 volts. They should preferably be of the indicating type. Snap-switches are, since the contact-bars and jaws are enclosed, usually safer from the standpoints of both life and fire hazard than are the ordinary types of knife switches.

148. Snap Switches, When Used In Knob And Cleat Work, Must Be Supported By Sub-bases (Code Rule 24*f*) of

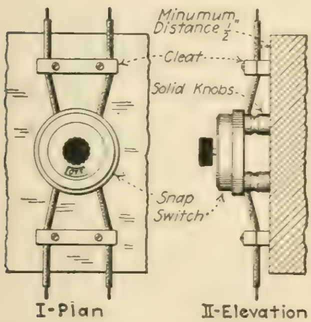


Fig. 158.—Snap switch mounted on porcelain knobs in knob and cleat work.

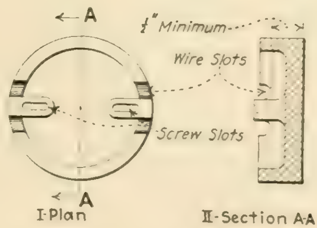


Fig. 159.—Porcelain sub-base for mounting snap switch in exposed knob and cleat work.

non-combustible, non-absorptive insulating material. The sub-base must be so designed that the wires will be separated (Figs. 158 and 159) from the surface wired over by a distance of at least 1/2 in. This is intended to prevent the wires from touching the surface which supports the knobs or cleats.

149. Snap-switch Sub-bases Must Be Used In Raceway Work, except that when the switch is so constructed that it is approved for mounting directly on the moulding, the sub-base may be omitted (Code Rule 24*f*). Raceway-work sub-bases are frequently made of porcelain (Figs. 160 and 161) although they may be of hard wood.

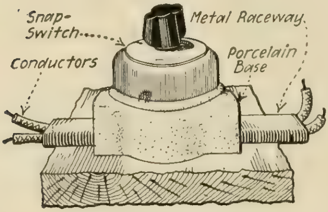


Fig. 160.—Snap switch mounted on porcelain base for metal-raceway work.

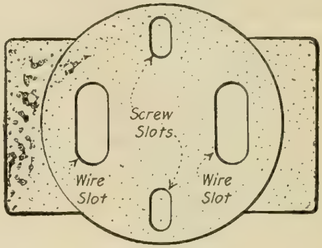


Fig. 161.—Porcelain sub-base for snap switch in metal-raceway work.

150. A Switch Must Be Used To Control Each Heating Appliance (Code Rule 25*a*, 2) or each group of heating appliances which have a capacity of more than 6 amp. or 660 watts. This switch must: (1) *Plainly indicate whether current is "on" or "off."* (2) *Be within sight of the heating appliance and readily accessible in case of emergency.* (3) *Disconnect all wires of the circuit.* This necessitates the use of a multi-pole switch. The single-pole switches on the individual units of an electric range are not to be considered as taking the place of the switch which is specified above.

Note.—An Approved Attachment Plug May Be Used Instead Of The Switch Mentioned Above provided the rating of such a plug does not exceed 30 amp.

Note.—Portable Heating Appliances Must Have Plug Connectors (Code Rule 25*b*, 2), so arranged that the plug may be pulled out to open the circuit. The plug must be so designed that no live parts are exposed, either when it is connected to the appliance or when disconnected therefrom. The connector may be located at either end of the flexible conductor, or inserted in the conductor itself.

151. Fuses May Be Classified as: (1) *Open link*, (Fig. 162). (2) *Enclosed*, (Fig. 163). Enclosed fuses may be further classified as: (*a*) *Edison-plug type*, (Fig. 163-*I*). (*b*) *Ferrule-contact type* (Fig. 163-*II*). (*c*) *Knife-blade-contact type*, (Fig.

163-*III*). The knife-blade and ferrule type fuses are also sometimes called *cartridge fuses*. The more-frequently-

Fig. 162.—Open-link fuses for cutouts, switches, and panel-boards.

encountered requirements of the Code which relate to fuse installation are treated in the following sections.

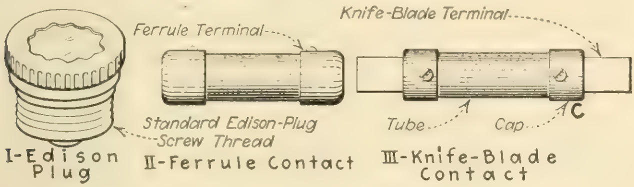


Fig. 163.—Various types of approved enclosed-fuses.

152. Link Fuses, when ruptured by an overload current, produce a heavy arc and throw molten metal about. Hence, unless properly mounted and enclosed (Sec. 158), they provide a dangerous fire hazard. Because of their low cost, they are well adapted for, and give good results in certain industrial plants where they are under expert supervision. They should not, however, be installed in residences, office buildings, or in any location where they may be handled by uninformed persons.

Note.—The Code Does Not Permit The Use Of Link Fuses which have a capacity exceeding 1,000 amp. nor which operate at a pressure in excess of 250 volts.

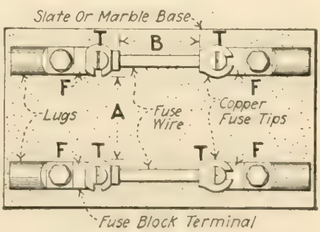


Fig. 164.—Two-pole open-link fuse cutout. (See Table 154 for significance of reference letters *A* and *B*.)

153. The Spacings Of Open Link Fuses must not be less than those given in Table 154 (Code Rule 67*a*). The distances, as given, apply only to plain open fuse-blocks, mounted on slate or marble bases, and are to be measured between the nearest metal parts (Fig. 164), exclusive of the fuse wire

proper. That is, if the copper fuse-tips, *T*, overhang the edges of the fuse-block terminals, *F*, the spacing is measured between the nearest edges of the tips.

154. Table Of Spacing Distance For Link Fuse Cutout Bases. (Code Rule 67*a*.)

Ampere capacity	Minimum separation of nearest metal parts of opposite polarity, *A*, Fig. 164, inches	Minimum break distance, *B*, Fig. 164, inches
Not over 125 volts		
0–10	¾	¾
11–100	1	¾
101–300	1	1
301–1,000	1¼	1¼
Not over 250 volts		
0–10	1½	1¼
11–100	1¾	1¼
101–300	2	1½
301–1,000	2½	2

Note.—The Required Spacing Between Open Link Fuse Terminals Of The Same Polarity (Code Rule 67*a*) is at least ½ in. for voltages up to and including 125 volts, and at least ¾ in. for voltages between 126 and 250 volts. This is the minimum distance allowable. Greater separation than that given above should be provided when it is practicable to do so. These spacings are intended to prevent the melting of a link fuse by the blowing of an adjacent fuse of opposite polarity.

155. The Spacing For Open-link Cutout Bases When Used In Three-wire Systems must (Code Rule 67*a*) be at least equal to the distance as given in Table 154 for circuits of the potential of the outside wires, except that the cutouts in a 125-volt two-wire branch (Sec. 171) of a 125-250-volt-grounded-neutral system may have the spacings as specified for not over 125 volts.

156. Bases For Link-fuse Cutouts must conform to the requirements as given in Sec. 121 for switch bases, except that

the holes for the supporting screws must be kept outside of the area bounded by the outside edges of the fuse-block terminals. That is, a screw located at *S*, Fig. 126, would not be permitted in a link-fuse cutout base.

157. Link Fuses Must Be Stamped (CODE Rule 68*b*) with a number indicating 80 per cent. of the maximum current, in amperes, which they can carry indefinitely. This allows about 25 per cent. overload before the fuse will melt. Thus, a link fuse which is rated at 80 amp., must, to comply with the CODE requirements, carry indefinitely a current of 100 amp. without rupturing.

NOTE.—THE CONTACT TERMINALS OF LINK FUSES must be of copper or aluminum, (CODE Rule 68*a*) and must have perfect electrical connection (soldered or welded) with the fusible part of the strip.

158. Link Fuses May Be Used (CODE Rule 23*c*) only on switchboards, or when mounted on *approved* bases which must be installed (Fig. 165) in approved cutout boxes or cabinets. When they are mounted on switchboards, the cabinet and the cutout base are not required. When installed in *approved* cutout boxes or cabinets, a space of at least 2 in. (Fig. 165) must be provided between all points on the open link fuse (either the fuse-wire proper or terminals thereof) and any part of the cabinet, such as the metal walls, metal-lined walls, doors, or the glass-paneled doors.

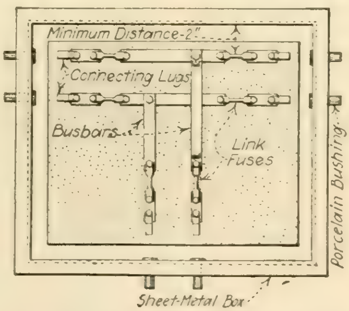


FIG. 165.—Two-wire cutout box with link fuses.

159. The Fuse Terminals Of An Enclosed-fuse Cutout Base must, except for sealable service and meter cutouts, (CODE Rule 67*b*) be of either the *Edison-plug* (Fig. 166-*I*), *spring-clip* (Fig. 166-*II*), or *knife-blade type* (Fig. 166-*III*), to take the corresponding standard enclosed fuses. The spring-clip and knife-blade type of fuse terminals must be secured to the base by two screws (Fig. 166) or the equivalent thereof, so as to prevent them from turning. *End stops* must be provided for the cartridge-type fuse terminals to insure proper

location of the fuse in the cut-out base. This is, in the knife-blade fuse, provided by the cap, (*C*, Fig. 163) which fits against the jaws of the terminal, and in the ferrule type, by a small lip of turned-over metal (*E*, Fig. 166-*II*), on each spring-clip, against which the ferrule-contact abuts.

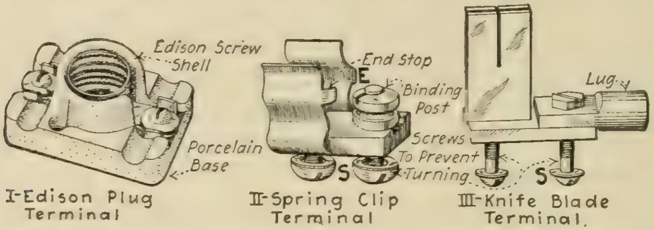


Fig. 166.—Types of approved fuse-terminal receptacles for enclosed fuses.

Note.—Sealable Service And Meter Cutouts are cutouts which are installed under the seal of a lighting company, and are therefore only accessible to and handled by experienced persons. The fuse terminals of such a cutout need not conform to the styles as mentioned above. An enclosed fuse having terminals which may be used for this class of service is illustrated in Fig. 167. It is obvious that when installed by a properly informed person, better contact may be provided by the correct adjustment of the holding-nuts, than may ordinarily be obtained by the use of the ferrule or knife-blade type of fuse.

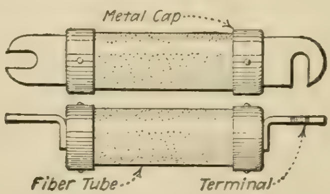


Fig. 167.—Type of enclosed fuse which may be used for service and meter cutouts when installed under seal of lighting company.

160. Every Approved Enclosed-fuse Cutout Base Is Rated In Regard To Both Current And Voltage in accordance with some one of the 19 standard ratings shown in Table 161 (Code Rule 67*c*). The bases are so designed (see Table 166) that one of a certain rating cannot be used with fuses which have either a higher voltage—or a higher current-rating.

Example.—A cutout base which is rated at 31–60 amp., 250 volts, must be so constructed that it is impossible to fuse it with a 65-amp., 250-volt fuse, or with any 600-volt fuse, even though the ampere-rating of the 600-volt fuse is less than that of the cutout-base rating.

161. Table Showing Classification Of Cutout Bases For Enclosed Fuses. (Code Rule 67*c*.) See note below.

Rating number	Not over 250 volts, amperes	Rating number	Not over 600 volts, amperes
Standard Plug or Cartridge Cutouts			
1	0–30	7	0–30
2	31–60	8	31–60
3	61–100	9	61–100
4	101–200	10	101–200
5	201–400	11	201–400
6	401–600		
Sealable Service and Meter Cutouts			
12	0–30	16	0–30
13	31–60	17	31–60
14	61–100	18	61–100
15	101–200	19	101–200

Note.—The above Rating Numbers 1 to 19 inclusive have been assigned arbitrarily by the author and are not authorized by nor do they appear in the Code. Every approved enclosed-fuse cutout base conforms to one of the 19 above ratings.

162. An Approved Enclosed Fuse Is Marked With: (1) *The words* "N.E. Code Std." (2) *The voltage and current rating.* (On ferrule-contact fuses, this marking is on the ferrule or the tube, and on knife-blade-contact fuses, it is on the cap or the tube.) (3) *A paper label* (for cartridge fuses) which is green in color for 250-volt fuses, and red for 600-volt fuses. This paper label must bear the name or trademark of the manufacturer and the voltage for which the fuse is designed.

163. The Style Or Type Of Terminals For Enclosed Fuses, Fig. 163, (except for sealable service and meter cutouts, Sec. 159) must correspond to that specified in Table 164 (Code Rule 68*f*).

164. Table Of Current And Voltage Classification For The Various Types Of Approved Enclosed Fuses And Fuse Terminals (except for sealable service and meter cutouts). See following notes.

Rating number	Ampere rating	Type of fuse and terminal
		Not over 250 volts
1	0–30	*A.* Cartridge fuse (ferrule contact). *B.* Approved plugs, or cartridge fuses in approved casings for Edison plug cutouts, not exceeding 125 volts, but including any circuit of a three-wire 125–250-volt system with grounded neutral.
2	31–60	Cartridge fuse (ferrule contact) for use also in approved casings for large size Edison plug type 250-volt cutouts.
3 4 5 6	61–100 101–200 201–400 401–600	Cartridge fuse (knife blade contact).
		Not over 600 volts
7 8	0–30 31–60	Cartridge fuse (ferrule contact).
9 10 11	61–100 101–200 201–400	Cartridge fuse (knife blade contact).

Note.—The "Rating Numbers" 1 to 11 inclusive were assigned by the author and do not appear in the Code. These correspond with the 11 rating numbers given in Table 161 for "Standard Plug Or Cartridge Cut-outs." A different-size approved Code standard cutout base is manufactured for each of these 11 ratings as shown in Table 165 and in addition Edison-plug-cutout bases are manufactured for ratings numbers 1 and 2.

Note.—The Above Classification Of Enclosed Fuses May Be Summarized As Follows:

1. The maximum voltage is 600 volts.

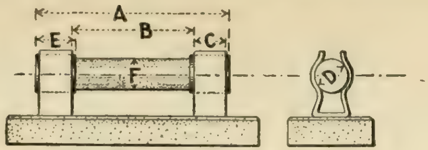
2. The maximum current-carrying capacity is 600 amp. at 250 volts, and 400 amp. at 600 volts.

3. The maximum rating of the Edison-plug type is 60 amp. at 250 volts.

4. The maximum rating of the ferrule-contact type is 60 amp. at 600 volts.

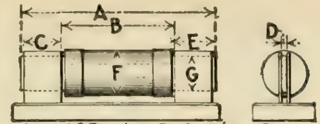
5. The minimum current rating of the knife-blade-contact type is 61 amp. (actually 65 amp., since the smallest fuse regularly manufactured in this class is of 65-amp. capacity).

165. Table Of Dimensions Of The National Electrical Code Standard Cartridge Enclosed Fuse.



Style Of Terminal For Cartridge Fuses 0-60 Amperes

FIG. 168.—Form 1. Cartridge fuse—ferrule contact.



Style Of Terminal For Cartridge Fuses 61-600 Amperes

FIG. 169.—Form 2. Cartridge fuse—knife-blade contact.

Voltage	Rating number	Rated capacity, amperes	Form number	*A* Length over terminals, inches	*B* Distance between contact clips, inches	*C* Width of contact clips, inches	*D* Diameter of ferrules or thickness of terminal blades, inches	*E* Min. length of ferrules or of terminal blades outside of tube, inches	*F* Dia. of tube, inches	*G* Width of terminal blades, inches	Rated capacity, amperes
Not over 250	1	0–30	Form 1	2	1	1/2	9/16	1/2	1/2	. . .	0–30
	2	31–60		3	1 3/4	5/8	13/16	5/8	3/4	. . .	31–60
	3	61–100	Form 2	5 7/8	4	7/8	1/8	1	1	3/4	61–100
	4	100–200		7 1/8	4 1/2	1 1/4	3/16	1 3/8	1 1/2	1 1/8	101–200
	5	201–400		8 5/8	5	1 3/4	1/4	1 7/8	2	1 5/8	201–400
	6	401–600		10 3/8	6	2 1/8	1/4	2 1/4	2 1/2	2	401–600
Not over 600	7	0–30	Form 1	5	4	1/2	13/16	1/2	3/4	. . .	0–30
	8	31–60		5 1/2	4 1/4	5/8	1 1/16	5/8	1	. . .	31–60
	9	61–100	Form 2	7 7/8	6	7/8	1/8	1	1 1/4	3/4	61–100
	10	101–200		9 5/8	7	1 1/4	3/16	1 3/8	1 3/4	1 1/8	101–200
	11	201–400		11 5/8	8	1 3/4	1/4	1 7/8	2 1/2	1 5/8	201–400

NOTE.—The 11 Rating numbers have been assigned by the author and are not authorized by the CODE.

166. The Dimensions Of Cartridge Enclosed Fuses, except for sealable service and meter cut-outs, must conform to those specified in Table 165. The reference letters in Table 165 refer to Figs. 168 and 169.

Note.—For Spacing Distance Between Parts Of Opposite Polarity Of Enclosed Fuses see Column 2, Table 125 (Code Rule 69*b*). Parts of enclosed fuses of the same polarity may be located as close together as convenience in handling will allow.

167. Automatic Cutouts (Fuses Or Circuit Breakers) Must Be Placed In All Ungrounded Service Wires (Code, Rule 23*a*) in the nearest accessible place, as shown in Fig. 135, to the point where the service enters the building, and arranged to cut off the current from all circuits and devices within the building except the service switch (Sec. 134, Fig. 136). Under the conditions shown in Fig. 137, both meter and switch may be so connected that they will not be disconnected by the service cutout. This is to enable an uninformed person to disconnect (by the opening of the service switch) the fuses from the source of voltage when installing a new fuse, thus tending to decrease the probability of an accidental short circuit, and a possible consequent fire or personal injury. In the approved combination of compact devices (Sec. 134), the fuses are usually enclosed in a metal cabinet which is sealed by the lighting company, and it is therefore presumed that live parts are accessible only to experienced persons who will not establish accidental short circuits. Thus, the internal connections of such a device may be arranged in any desired manner that will facilitate the manufacturing or installation requirements.

Note.—The Yard Wires Which Extend From Building To Building In A Private Plant Are Not Considered As Service Wires, and need not be fused at the building-entrance provided that the next fuse back toward the source of energy is small enough to protect the wires inside the building in question according to Table 170. See Note under Sec. 133.

168. Service Fuses Must Be Enclosed (Code Rule 23*a*) so that live parts are not exposed to accidental contact, except that when they are mounted on switchboards which are subject

to competent supervision they need not be enclosed. The term "enclosed," in the sense herein implied, means contained in an approved non-combustible or sheet-metal box or cabinet (Figs. 137 and 140) and does not mean an "enclosed-fuse."

169. Fuses Must be Placed At Every Point Where A Change Is Made In The Wire-size, (CODE Rule 23*b*) unless the fuse (Fig. 170) in the larger wire will protect the smaller wire. Such a fuse must, for the given size of the wire which it is to protect, have a rated capacity which does not exceed that specified under the column headed Table *A*, *B*, or *C*, of Sec. 170, according to the insulation of the wire.

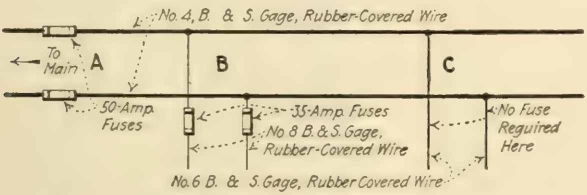


FIG. 170.—Illustrating CODE requirement for fusing wires at points where the wire-size changes. (Such an arrangement of wire sizes as shown herein would usually be uneconomical and undesirable. It is only shown for explanation purposes.)

EXAMPLE.—THE CODE REQUIREMENTS FOR FUSING WIRES AT POINTS WHERE A CHANGE IS MADE IN THE SIZE OF THE WIRE is illustrated in Fig. 170. In this illustration, a No. 6, B. & S. gage, rubber-covered wire is connected to a No. 4 B. & S. gage, rubber-covered wire at *C*, and a No. 8, B. & S. gage, rubber-covered wire is connected to the No. 4, at *B*. The No. 4 wire, which safely carries 70 amp. (Table *A*, Sec. 170), is fused at *A* with a 50-amp. fuse, which will, according to Table *A*, Sec. 170, protect a No. 6 rubber-covered wire which safely carries 50 amp. Therefore, no fuse is required at *C* because the No. 6 wire is protected by the fuse at *A*. The No. 8 wire (capacity = 35 amp.) must be fused at *B* with a fuse not greater than 35 amp., since it will not be protected by the 50-amp. fuse at *A*.

170. Table Showing Maximum Allowable Current-carrying Capacity Of Solid Copper Wires. (CODE Rule 18.)

B. & S. Gage No.	Dia. of solid wire in mils	Area in circular mils	Table *A.* Rubber insulation, amperes	Table *B.* Varnished cloth insulation, amperes	Table *C.* Other insulation amperes
18	40.3	1,624	3	....	5
16	50.8	2,583	6	....	10
14	64.1	4,107	15	18	20
12	80.8	6,530	20	25	25
10	**101.9**	**10,380**	**25**	**30**	**30**
8	128.5	16,510	35	40	50
6	162.0	26,250	50	60	70
5	181.9	33,100	55	65	80
4	204.3	41,740	70	85	90
3	**229.4**	**52,630**	**80**	**95**	**100**
2	257.6	66,370	90	110	125
1	289.3	83,690	100	120	150
0	325.0	105,500	125	150	200
00	364.8	133,100	150	180	225
000	**409.6**	**167,800**	**175**	**210**	**275**
....	....	200,000	200	240	300
0000	460.0	211,600	225	270	325
....	....	250,000	250	300	350
....	....	300,000	275	330	400
....	....	**350,000**	**300**	**360**	**450**
....	....	400,000	325	390	500
....	....	500,000	400	480	600
....	....	600,000	450	540	680
....	....	700,000	500	600	760
....	....	**800,000**	**550**	**660**	**840**
....	....	900,000	600	720	920
....	....	1,000,000	650	780	1,000
....	....	1,100,000	690	830	1,080
....	....	1,200,000	730	880	1,150
....	....	**1,300,000**	**770**	**920**	**1,220**
....	....	1,400,000	810	970	1,290
....	....	1,500,000	850	1,020	1,360
....	....	1,600,000	890	1,070	1,430
....	....	1,700,000	930	1,120	1,490
....	....	**1,800,000**	**970**	**1,160**	**1,550**
....	....	1,900,000	1,010	1,210	1,610
....	....	2,000,000	1,050	1,260	1,670

NOTE.—FIXTURE WIRE OR FLEXIBLE CORD of No. 18 B. & S. gage will be considered as properly protected when fused with 10-amp. fuses (CODE Rule 23*d*).

171. Fuses Must Not Be Placed In Any Permanently Grounded Wire, except that where a two-wire branch or tap,

which is directly connected to lamp sockets, connects to one outside wire and to the permanently grounded neutral of a three-wire system, both wires of such a tap or branch must be

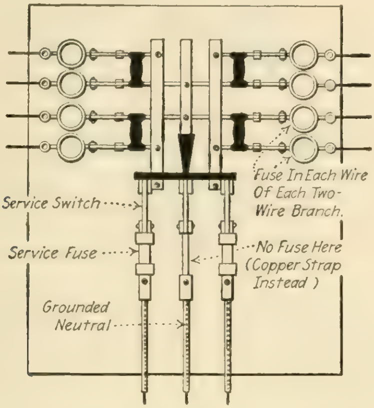


Fig. 171.—Distribution panel for a 110–220 volt, three-wire grounded-neutral system, showing fuse arrangement to comply with Code requirements.

protected by fuses. A correct arrangement is shown in Fig. 171. The omission of the fuse in the neutral wire may be accomplished by the various methods as shown in Figs. 172, 173, and 174.

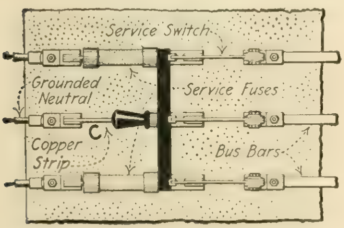


Fig. 172.—Copper strip, *C*, inserted in the fuse-block jaws of the neutral and soldered thereto. Such a copper strip is used in lieu of a fuse in the grounded neutral of a three-wire system.

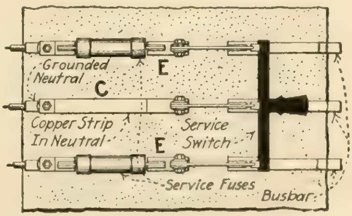


Fig. 173.—Copper strip, *C*, permanently secured to base, substituted for fuse.

Note.—Suppose A Three-wire, Grounded-neutral System Had A Fuse In The Neutral and had no fuses in the two-wire branches, as shown in Fig. 175. Then, if a short-circuit occurred, say at *D*, fuse *A* of the neutral might be "blown," or ruptured. This would result in a potential difference of 220 volts being impressed on circuit *C*.

The least damage that could then occur would be the destruction of all lamps connected to circuit *C*. Provisions are therefore made to prevent

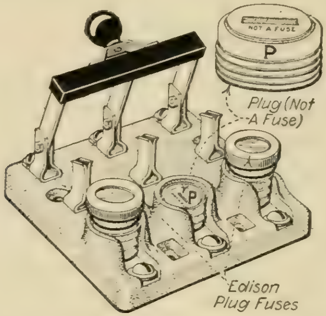


Fig. 174.—The plug, *P*, when screwed into the neutral-wire cutout provides a means of bridging this cutout, thus connecting the neutral through this cutout, "solid." (After installation the manufacturer recommends that the plug should be soldered therein. *Bryant Electric Co.*)

such an occurrence by so constructing the neutral that it will always remain intact except when the outside wires are opened by the switch (see Sec. 137).

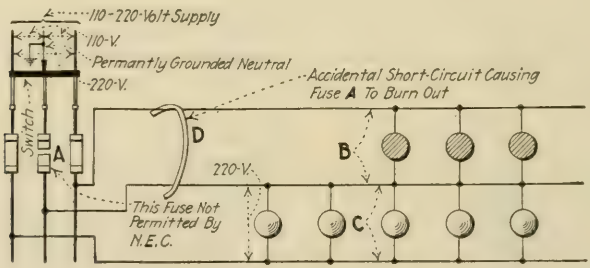


Fig. 175.—Showing probable results in a 110–220 volt, three-wire, grounded-neutral system when not fused according to Code requirements.

172. Branch And Tap Circuits Must Be So Fused (Code Rule 23*d*) that (with the exceptions recited below) no set of small motors, small heating devices, or incandescent lamps, whether grouped on one or several fixtures or pendants, requiring more than 660 watts, will be dependent upon one cutout. On a purely lighting circuit, 16 medium or 25 candelabra size sockets are, in the interpretation of this rule, assumed not to require more than 660 watts. Branch and tap

circuits usually consist of No. 14 B. & S. gage wire, which, if rubber-covered, has a safe carrying capacity (Table *A*, Sec. 170) of 15 amp. It would seem permissible to protect such a circuit with 15-amp. fuses. However, there is usually attached to the circuit No. 18 flexible cord or fixture wire, which has an actual safe current-carrying capacity of only 3-amp. If a short-circuit or ground occurred on this flexible cord, or within a socket, the No. 18 wire might attain a sufficient temperature to incur a dangerous fire hazard before the 15-amp. fuse would burn out. Such a circuit may be (CODE Rule 25*a*), and usually is, fused with 10 amp. fuses. Another reason for the 660-watt rule is that the small switches, such as single-pole, key-socket, three- and four-way switches, which are ordinarily used on such circuits, are not designed for rupturing any considerable amount of energy, and must be protected by suitable fuses which will limit the energy through them.

NOTE.—IT IS POSSIBLE THAT THE 1923 CODE (see Sec. 118) will permit a maximum of 12 outlets on one branch circuit and that such branch circuits may be fused as follows: 15-amp. fuse at 125 volts or less; 10-amp. fuse at 126 to 250 volts.

173. Where Only One Socket Or Receptacle Is Used On A Circuit, (CODE Rule 23*d*) the maximum permissible wattage for the final fuse in that circuit shall not exceed the capacity, in watts, for which the socket or receptacle is approved.

EXAMPLE.—If a single flush receptacle, which is *approved* for 660 watts, is used on a 110-volt circuit, the fuse protecting that circuit must not exceed: $660 \div 110 = 6$ *amp.* This is to prevent an overloading of the receptacle which could be done by connecting thereto an energy-consuming device having, say a rating of 10-amp. at 110 volts.

174. Exceptions May Be Made, By Obtaining Special Permission, To The 660-Watt Rule as follows: (CODE Rule 23*d*).

A. Where No. 14 wire is carried direct into keyless sockets or receptacles, and where the location of such sockets or receptacles is such as to render unlikely the attachment of flexible cords thereto, the circuit may be so arranged that not

more than 1,320 watts (32 sockets or receptacles) may be dependent upon the final cut-out.

B. Circuits supplying sockets or receptacles of the Mogul type may be so arranged that not more than 4,000 watts will be dependent upon the final cut-out, provided that: (*a*) *The location of the sockets and receptacles is such as to render unlikely the attachment of flexible cords thereto.* (*b*) *That the sockets do not have a fibre or paper lining.*

Note.—Mogul Sockets And Receptacles, must be wired with conductors of a size not less than No. 12 B. & S. gage. The length of the taps from circuit wires to the point of suspension of such sockets, receptacles, and fixtures, must not exceed 18 in.

Note.—It Is Possible That The 1923-Code (see Sec. 118) will permit branch circuits supplying Mogul sockets to be fused as follows: 40-amp. fuses at 125 volts; 20-amp. fuses at 126 to 250 volts.

175. The Rated Capacity Of Fuses Protecting Branch Circuits shall not exceed the values given in the following table (Code Rule 23*d*): (See notes about 1923 Code under Secs. 172 and 174.)

Voltage	Circuit not exceeding	
	660 watts	1,320 watts
125 or less	10 amp.	20 amp.
125 to 250	6 amp.	10 amp.

Note.—Fused Rosettes May Be Used only for open work in large mills (Code, Rule 23*d*). *Approved* link-fused rosettes are not permitted for use at pressures exceeding 125 volts. *Approved* enclosed-fused rosettes are not permitted for operation at over 250 volts. For both link-fused and enclosed-fused rosettes, the fuse in the rosette must not have a rating greater than 3 amp.; a fuse of over 25-amp. capacity must not be used in the branch circuit containing such rosettes.

176. Table Showing Size Of Conduit For The Installation Of Wires And Cable. (CODE, Rule 28*i*).

Size of conductor. B. & S. gage	Number of conductors in one conduit								
	1	2	3	4	5	6	7	8	9
	Minimum size of conduit in inches								
14	½	½	½	¾	¾	1	1	1	1
12	½	½	¾	¾	¾	1	1	1	1¼
10	½	¾	¾	1	1	1	1¼	1¼	1¼
8	½	¾	1	1	1	1¼	1¼	1¼	1¼
6	½	1	1¼	1¼	1½	1½	2	2	2
5	¾	1¼	1¼	1¼	1½	2	2	2	2
4	¾	1¼	1¼	1½	2	2	2	2	2½
3	¾	1¼	1¼	1½	2	2	2	2½	2½
2	¾	1¼	1½	1½	2	2	2½	2½	2½
1	¾	1½	1½	2	2	2½	2½	3	3
0	1	1½	2	2	2½	2½	3	3	3
00	1	2	2	2½	2½	3	3	3	3½
000	1	2	2	2½	3	3	3	3½	3½
0000	1¼	2	2½	2½	3	3	3½	3½	4
200,000 C.M.	1¼	2	2½	3	3	3	3½	3½	4
225,000	1¼	2½	2½	3	3	3½	3½	4	4
250,000	1¼	2½	2½	3	3	3½	3½	4	4½
300,000	1¼	2½	3	3	3½	3½	4	4½	4½
350,000	1¼	2½	3	3½	3½	4	4½	4½	5
400,000	1¼	3	3	3½	4	4	4½	5	5
450,000	1½	3	3	3½	4	4½	4½	5	6
500,000	1½	3	3	3½	4	4½	5	5	6
550,000	1½	3	3½	4	4½	5	5	6	6
600,000	2	3	3½	4	4½	5	6	6	6
650,000	2	3½	3½	4	4½	5	6	6	6
700,000	2	3½	3½	4½	5	5	6	6	
750,000	2	3½	3½	4½	5	6	6	6	
800,000	2	3½	4	4½	5	6	6	6	
850,000	2	3½	4	4½	5	6	6		
900,000	2	3½	4	4½	5	6	6		
950,000	2	4	4	5	6	6	6		
1,000,000	2	4	4	5	6	6			
1,100,000	2½	4	4½	6	6				
1,200,000	2½	4½	4½	6	6				
1,250,000	2½	4½	4½	6	6				
1,300,000	2½	4½	5	6	6				
1,400,000	2½	4½	5	6					
1,500,000	2½	4½	5	6					
1,600,000	2½	5	5	6					
1,700,000	3	5	5	6					
1,750,000	3	5	5	6					
1,800,000	3	5	6	6					
1,900,000	3	5	6						
2,000,000	3	5	6						

Note.—The values contained in the above table apply only to complete conduit systems. They do not apply to short sections of conduit used for protection of exposed wiring from mechanical injury.

176A. Polarity Identification of Rubber-covered Wire is shown in Fig. 175*A*. Rule 26*a* of the 1920 Edition of

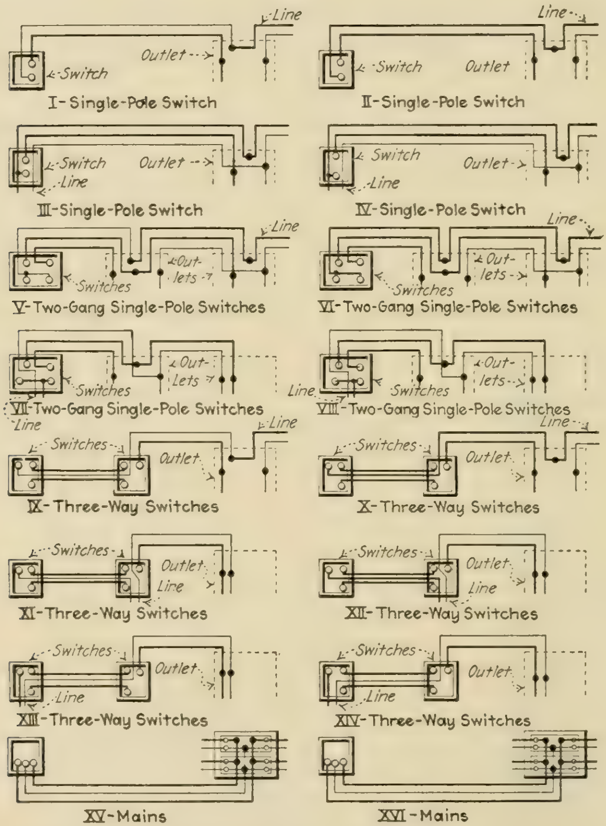


Fig. 175*A*.—Showing how "polarity-identification" rubber-covered wire is connected in interior wiring.

the Code reads as follows: "(*After July* 1, 1921) *One conductor of twin rubber-covered wires of No. 12 and No. 14 sizes, and of twisted pair wires of armored cable must have a continuous identifying marking readily distinguishing it from the other conductor. When one of the circuit wires is to be grounded,*

the ground connection must be made to this identified wire and as prescribed in Nos. 15 *and* 15*A*." In the accompanying diagrams (Fig. 175*A*) illustrating the use of the marked wires referred to in the above rule, the heavy line represents the black-covered and live wire, and the light line, the identified and grounded wire.

NOTE.—IT IS PROBABLE THAT THE 1923-CODE (see note under Sec. 118) will require: "For conductor sizes No. 8 and smaller, the neutral conductor on all three-wire circuits and one conductor on all two-wire circuits shall have a continuous identifying marker readily distinguishing it from the other conductors." Furthermore, "When one of the circuit wires is grounded, the ground connection must be made to this identified wire."

QUESTIONS ON DIVISION 3

1. What is the NATIONAL ELECTRICAL CODE?

2. Why is compliance with CODE requirements usually necessary?

3. What constitutes an *approved* device?

4. What markings must be placed on knife switches?

5. What properties must knife-switch bases possess?

6. What are the requirements which apply to knife-switch bases? To open-link-fuse bases?

7. Show by sketch, the meaning of *break distance* and of *distance between parts of opposite polarity*.

8. Why are 300-amp. knife switches permitted for use on switchboards only?

9. Explain, by sketch, *parts mounted on same surface; parts mounted clear of surface*.

10. How must the jaws of a knife switch be secured to the base? Why?

11. How may switches which have a rating in excess of the maximum approved enclosed-fuse rating be fused with enclosed fuses?

12. What is a switch barrier? What is its function? Illustrate with a sketch.

13. Why must the insulation distance be greater between the break-jaws of a knife switch than between the hinge-jaws?

14. Show by sketch how the required spacing may be obtained between the hinge-jaws of a front-connected, multi-pole switch.

15. What is a quick-break switch? In excess of what current and voltage rating is its use required?

16. What is a service switch? What are the requirements which pertain to its location?

17. Show by sketch how a service switch must be wired in respect to its service fuses and meter. What are the exceptions thereto?

18. When must, and when may not service switches be enclosed?

19. What is considered to be an *accessible place* for a service switch?

20. Show by sketch the position in which a single-throw knife switch should be vertically mounted with respect to the source of voltage. A double-throw switch.

21. How should a knife switch be wired as regards the blades? Make a single sketch graphically answering questions 17, 20 and 21.

22. Why should a single-pole switch never be used in the grounded-neutral of a three-wire main or feeder?

23. Show by a sketch and explain why a double-pole switch is preferable to a single-pole for use in controlling a two-wire branch of a three-wire, grounded-neutral system.

24. Name the various types of switches which must be considered as single-pole switches to comply with *Code* requirements.

25. Show by sketches how the following flush switch boxes should be installed in the lath-and-plaster partition of: (*a*) *A new building.* (*b*) *A finished building.* Also how the box for a baseboard outlet should be installed in a partition in a new frame building.

26. Why are snap switches preferable to knife switches for controlling lighting circuits of small capacity?

27. How may fuses be classified?

28. Why are link fuses frequently undesirable? Why are they well adapted for certain services?

29. With what per cent. of the maximum current which they can carry indefinitely are link fuses stamped?

30. Where may link fuses be used?

31. Name three types of approved enclosed-fuse cutout bases, and make a sketch and give the ratings of the terminal or holder for each.

32. What is a *sealable service and meter cutout?*

33. What are the markings which must appear on *approved* enclosed-fuses of the cartridge type?

34. Write a summary of the enclosed-fuse classification.

35. In generally-accessible service cutout boxes, why is the wiring such that the fuses are "dead" when the switch is open?

36. Explain by sketch why fuses should not be placed in a permanently grounded neutral and why each conductor of the two-wire branch of a three-wire grounded-neutral system should be fused?

37. Give reasons for the 660-*watt rule.* What are two exceptions to this rule?

DIVISION 4

SINGLE- AND MULTI-POLE SWITCH CIRCUITS

177. The Single- And Multi-pole Switch Circuits which are described in this division, include only those circuits which may be controlled by one-, two-, and three-pole switches, as are defined in Secs. 45 to 48. Both single- and double-throw switches are discussed. Although three-way, four-way, electrolier, and series-parallel switches are considered by the CODE (Div. 3) as single-pole switches, their applications (see Index) are treated elsewhere in this book.

178. The Most Frequent Use For The Single-pole Switch (Fig. 176) is probably for controlling a single lamp (Fig. 177) or a group of lamps (Fig. 178).

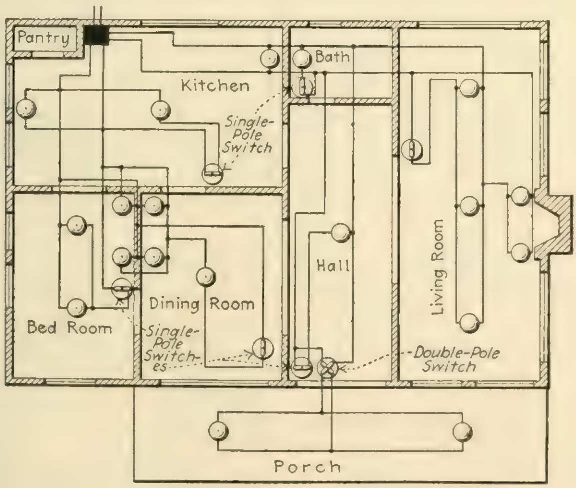


FIG. 176.—Showing use of single- and double-pole switches in a small residence.

NOTE.—LIGHTING-CIRCUIT CONTROL WITH KNIFE SWITCHES IS USUALLY UNDESIRABLE except in service or distribution boxes. However, knife switches are sometimes so used in emergencies, and also in laboratories and test-rooms. Although the CODE will permit the use of a knife

switch in any location provided it is properly installed, snap switches are, in locations other than those mentioned above, usually less expensive, more sightly, and also more convenient as regards installation and opera-

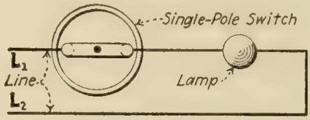


Fig. 177.—Single-pole switch controlling circuit of a single lamp. (Frequently a key socket.)

tion. It should be noted (see Div. 2) that snap switches, both in the rotary and push-button types, are manufactured which will, within their capacities, perform practically the same functions as will the various equivalent knife switches.

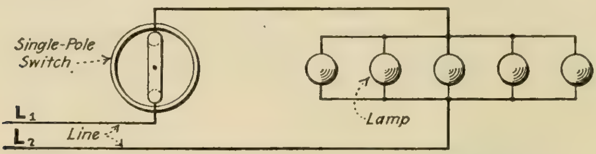


Fig. 178.—Single-pole switch controlling a group of lamps.

179. Two Single-pole Switches Connected In Series are shown in Fig. 179. The lamps may be extinguished with either switch, but both switches must be "on" to light the lamps. This method of connections may be employed where

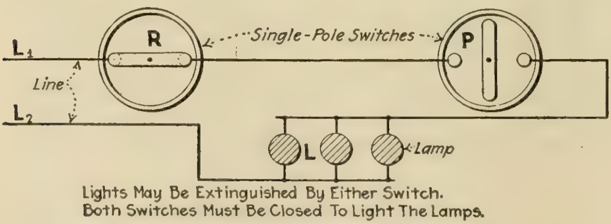


Fig. 179.—Two single-pole switches connected in series.

it is desired that the lighting of lamps be supervised from a remote point, *R*. That is, if it is desired that it be made impossible to light lamps *L* by the operation of *P*, switch *R*, which may be located anywhere, is left open. With *R* open,

the circuit cannot be closed with P. The same control as that of Fig. 179 is provided by connecting the lamps between the switches as shown in Fig. 180. Although in Fig. 180 both sides of the line can be opened by the two single-pole switches, S_1 and S_2, this arrangement does not comply with the CODE requirements relative to a double-pole switch opening both sides of the line.

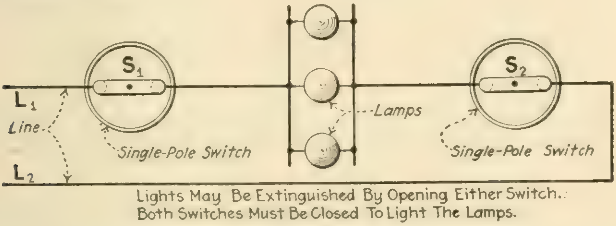


FIG. 180.—Two single-pole switches connected in series with lamps in parallel between the switches.

180. Two Single-pole Switches Connected In Parallel are shown in Fig. 181. Lamps thus controlled may be lighted by either switch, but both switches must be "off" to extinguish the lamps. Such an installation may be used where it is desired that the lighting (but not extinguishing) of a lamp, or of a group of lamps, be controlled from a distant location. This is (Sec. 56), in effect, and elementary *master switch*.

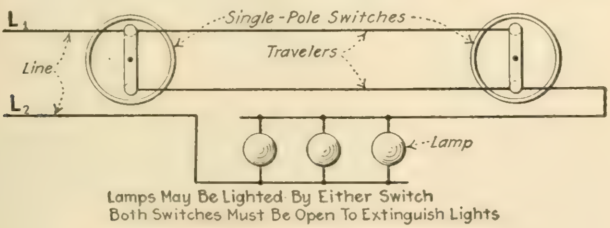


FIG. 181.—Two single-pole switches connected in parallel.

181. Two Single-pole Switches Using One Wire As A Common Return (Fig. 182) may be used for controlling two groups of lamps. If the lamps are located near each other, as on a chandelier, a wire-saving, which is equal to the distance from the switch to the chandelier, will be effected with the wiring of Fig. 182. This arrangement is essentially equivalent

to that of a two-circuit electrolier switch (Sec. 294) and may be used in lieu thereof. A convenient switch for this purpose is described in Sec. 90.

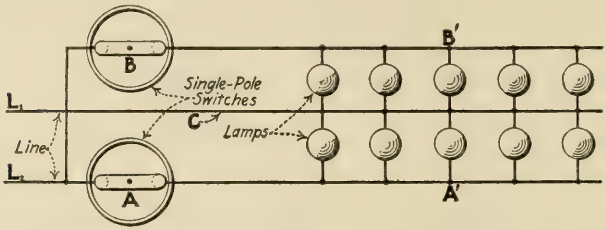


FIG. 182.—Two single-pole switches utilizing a common return, *C*, to control two groups of lamps. (Group *B′* is controlled by switch *B*. Group *A′* is controlled by switch *A*.

182. Connections For Two Single-pole Switches Connected In Series To Obtain Restricted-selective Control Of Lamps (Sec. 17) are shown in Fig. 183. Closing and opening switch *B* will alternately light and extinguish lamp *B′*. With *B* closed, successive operations of switch *A* will alternately light and extinguish, simultaneously, lamps *A′*. With *A*

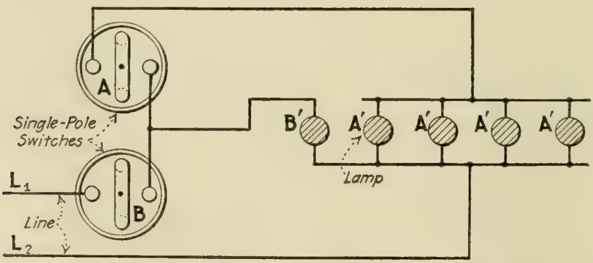


FIG. 183.—Group of lamps controlled by two single-pole switches. (Opening and closing *B* alternately lights and extinguishes *B′*. If *B* is closed, closing and opening *A*, alternately lights and extinguishes lamps *A′*. If *A* is closed, closing and opening *B*, alternately lights and extinguishes all lamps.)

closed, successive operations of *B* results in simultaneously lighting and extinguishing of all lamps in the entire group. As in Fig. 182, only three wires are required from the switches to the lamps. Although only a one-and-four-lamp control of a five-lamp group (Fig. 183) is shown, any two-group combination on any number of lamps may be arranged. A two-button push-switch, which is so connected internally that the

above-described control is provided, and which is contained in a single porcelain cup, is described in Secs. 90 and 299.

183. A Single-pole, Double-throw Switch May Be Used To Provide Dimming Of Lights as shown in Fig. 184. When the switch, D, is open, all lamps, A' and B', burn at one-half normal voltage. When the switch is closed to A, lamps A' are extinguished and lamps B' burn at full voltage. By closing

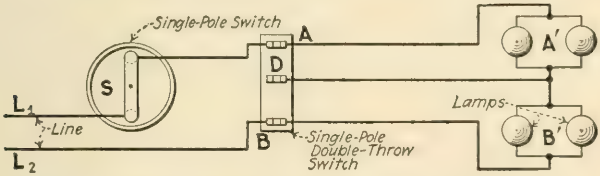


FIG 184.—Single-pole double-throw switch, connected for dimming.

the switch to position B, group B' is extinguished and group A' burns at full voltage. Note that the single-pole, double-throw switch, D, will not, when connected as shown, extinguish all of the lights; a second switch, S, must be provided for this purpose. This arrangement may be applicable for night or pilot-light service for long hall-ways or spacious rooms. It may also be used in store rooms, and other locations where it may be desirable to have available either an evenly-distributed

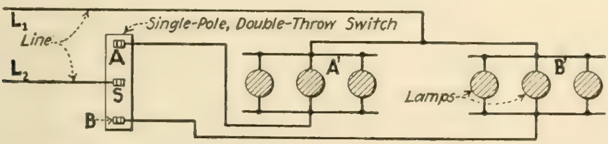


FIG. 185.—Single-pole double-throw switch connected so that only one group of lamps can be lighted at a time.

dim light or a more-concentrated bright light. It should be remembered that when incandescent lamps are burned at much less than normal voltage, they are very inefficient. With one-half normal voltage impressed on a lamp, its light output is much less than one-half normal. In fact, at half voltage, the filament of a tungsten lamp is only bright red in color.

184. Single-pole, Double-throw Switch Connections For A Restricted Lighting Circuit (Sec. 15) where only one group of lamps can be lighted at any one time are shown in Fig. 185.

With the switch, S, in the "open" position, neither group of lamps will burn. If the switch is closed to position A, group A' is lighted and B' is extinguished; if closed to position B, group B' is "on" and A' is "off."

185. A Single-pole, Double-throw Switch Connected To Provide Load-balancing On A Three-wire, Direct-current Circuit; A Three-wire, Single-phase Circuit; Or On A Three-wire, Two-phase Circuit is shown in Fig. 186. In *I*, the load is carried by side-circuit AB; in *II*, it is carried by BC. Thus, the switch, S, may be thrown so that the lighting-load will be carried by either of the "outside" wires and the neutral. If

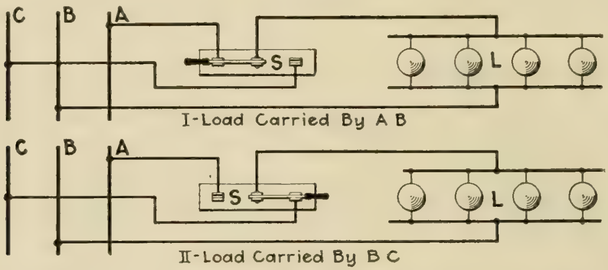


FIG. 186.—Single-pole, double-throw switch connected to provide load balancing on a three-wire direct-current circuit, a three-wire single-phase circuit or a three-wire two-phase circuit. In *I* the load, L, is carried by side circuit BA. In *II* the load is carried by side circuit CB.

either of the outside wires becomes broken, the load may be switched to the other outside wire and the neutral, and so carried until repairs are made. Or, if the load imposed by receivers on some other part of the system becomes excessive on one of the side circuits, the load of the receiver-group, L, (Fig. 186) may be shifted by throwing S to the other side circuit. Thereby balance may be partially or completely restored.

186. To Assist In Balancing The Load On Three-phase Lighting Mains, Single-pole, Double-throw Switches May Be Used as suggested in Fig. 187. Two switches are required for each branch which is to be shifted from phase circuit to phase circuit. With the two switches arranged on the single-phase branch circuit as shown, the load on the branch circuit may be connected between any of the three sets of phase-wires of the

three-phase main. By closing the switches to the positions (*I*, *II*, or *III*, Fig. 187) shown at *A′*, *B′*, or *C′*, the branch-circuit load, *L*, will be carried, respectively, by phase circuits *A*, *B*, or *C*. Note that if the switches are either both "open," or both closed to the right, the lights will be extinguished.

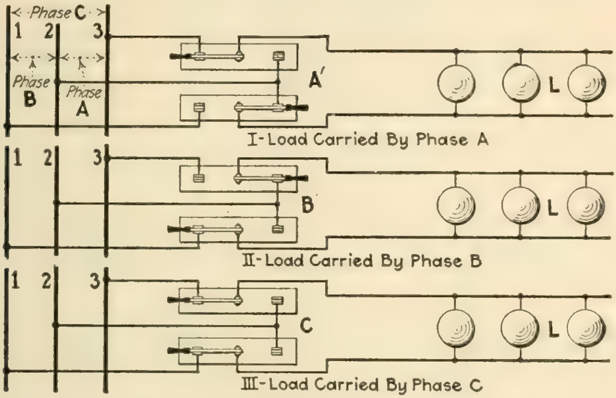


FIG. 187.—Two single-pole double-throw switches connected for balancing load on three-phase lighting mains. If both switches are open, or are closed to the "right," all lights will be "off."

187. Control Of Lights From Two Locations With Two Single-pole, Double-throw Knife Switches may be provided as shown in Figs. 188 and 189, or in Figs. 190 and 191. In Figs. 188 and 189, only one side of the line is connected directly

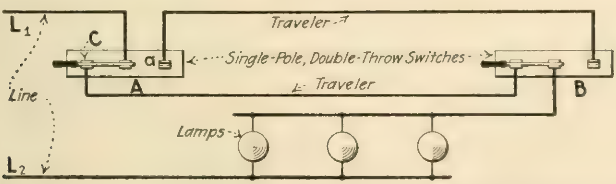


FIG. 188.—Two-location control of lamps with two single-pole double-throw switches. (Only one side of line, L_1, connected to switches.)

to the switches, while in Figs. 190 and 191, both sides are connected directly to each switch.

NOTE.—WHEN SINGLE-POLE, DOUBLE-THROW KNIFE SWITCHES ARE USED FOR TWO-LOCATION-LIGHTING-CONTROL, (Figs. 188, 189, 190 and

191), they should be so mounted that the throw of the switches will be horizontal rather than vertical (Sec. 140). For successful operation of

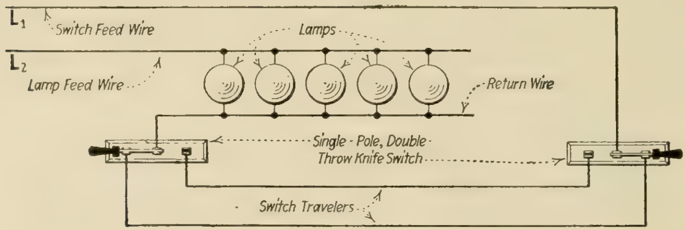


Fig. 189.—Single-pole, double-throw knife switches used instead of three-way switches for two-location control.

such an arrangement, both switches must always be closed. That is, if the lights are extinguished at switch *A*, (Fig. 188) by opening contact *c*,

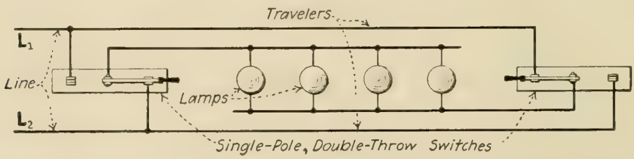


Fig. 190.—Two-location control of lamps with two single-pole double-throw switches. (Both sides of line connected to switches.)

the switch blade should then be closed to contact *a*. Otherwise, the lamps cannot be lighted by switch *B*.

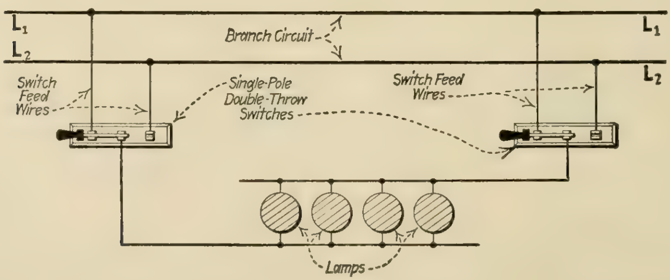


Fig. 191.—Single-pole double-throw knife switches used for two-location control.

188. One Of The Most Common Applications Of Multi-pole Switches is (Fig. 192) at distribution centers. The three-pole switch, *T*, controls the supply circuit which supplies the distri-

bution center, and therefore operates to extinguish all lights controlled by that center. The double-pole switches, *D*, control the branches or sub-feeders (see Sec. 142).

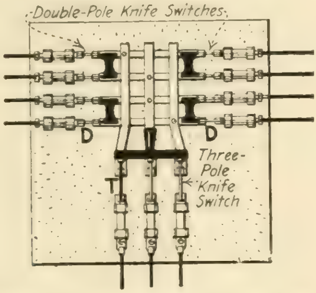


Fig. 192.—Showing application of three-pole and double-pole switches on a panel. The middle pair of fuse clips contains a solid copper conductor—not a fuse.

189. The Usual Double-pole Switch Connection is shown in Fig. 193. This is the method which is ordinarily used for the control of outdoor circuits, circuits located in damp places (Sec. 141), and for installations wherein it is necessary, or desirable, that both legs of the circuit be disconnected by the opening of the switch.

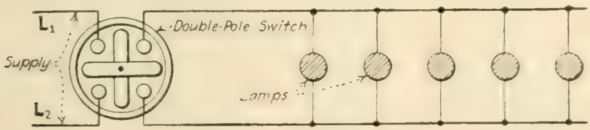


Fig. 193.—Ordinary double-pole switch connections for lighting-circuit control.

190. Two Double-pole Snap Switches May Be Connected In Parallel as shown in Fig. 195-*I*. This gives a result similar to the single-pole-switch arrangement of Fig. 181. Such an arrangement enables the lamps to be lighted by closing either switch, but both switches must be open to extinguish them. Common errors in connection, which will result in short-circuit as soon as both switches are closed, are shown in Fig. 195-*II* and *III*. Three or more double-pole switches may be connected in parallel by the method of Fig. 194.

Note.—Single-throw, Double-pole Knife Switches May Be Connected To Obtain The Same Control Effect As That Afforded

By Double-pole Snap Switches. However, errors (Sec. 198) in connections, which will result in a short-circuit, are not so likely to be made when knife switches are used as when snap-switches are used.

Note.—For The Usual Connections Of A Double-pole Snap Switch, the terminals marked "L" may be used as a guide; the line-wires

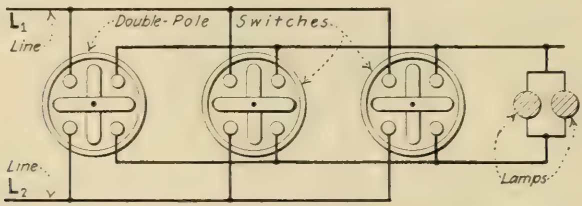


Fig. 194.—Method of connecting three or more double-pole switches in parallel. (Lamps may be lighted by closing any switch. All switches must be open to extinguish lights.)

should be connected thereto. However, when making special connections with such a switch, or to any switch to which both sides of the line are connected, extreme caution must be observed to prevent a short-circuit as in Fig. 195-*III*.

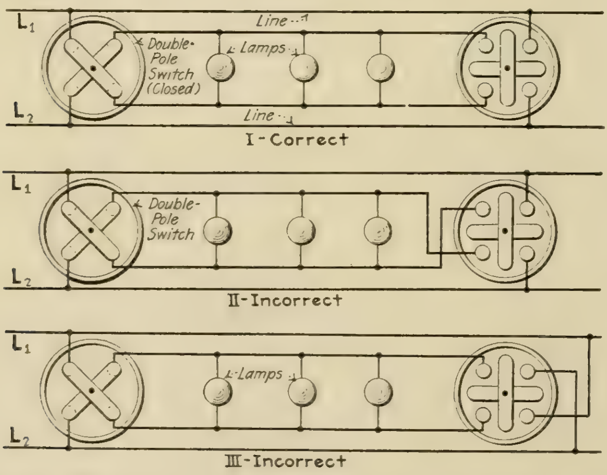


Fig. 195.—Correct and incorrect methods of connecting two double-pole snap switches in parallel. (Closing both switches in *II* or *III* will result in a short circuit.)

191. Double-pole Switches May Be Connected In Series as as shown in Fig. 196. Lamps thus controlled may be extinguished by opening either switch, but both switches must be

closed to light the lamps. The result is similar to that obtained with the single-pole-switch arrangement of Fig. 179.

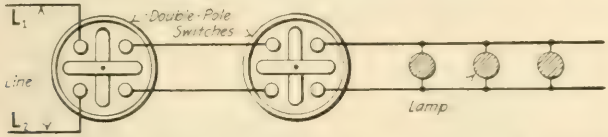


Fig. 196.—Double-pole switches connected in series. (Lights may be extinguished by opening either switch. Both switches must be closed to light lamps.)

192. A Series-parallel Method Of Connections For Double-pole Switches (Fig. 197) may be utilized for progressive or selective lighting, as in the corridors of basements. Neither lamp-group B' nor C' can be lighted until switch A is closed. However, all lights may be extinguished by opening A. Switches B and C, which control lamp-groups located in different corridors or passageways, should be so located with respect to the lamp-group A' that they are rendered visible by the light from A'. Thus, only the pathway which is

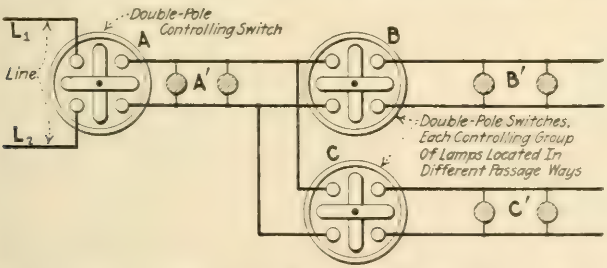


Fig. 197.—Double-pole switches connected in series-parallel, for use in progressive lighting of damp basements or out-door circuits.

traversed as a person enters and leaves the corridor, may be lighted, without the necessity of lighting all of the lamps on the branch circuit.

193. A Double-pole Switch May Be Connected To Provide Single-pole-switch Control as shown in Fig. 198. That is, although a double-pole switch, *DP*, is used, only one side of the line is disconnected when it is open. In Fig. 199 where a room has branches, *R*, in each end-partition and the specifications require that the switch be located near the door in the

center of the room, the principle outlined above may sometimes be applied to effect a wire-saving. By using a double-pole switch, connected as shown at *A*, instead of a single-pole,

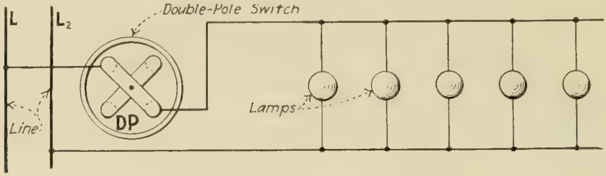


Fig. 198.—Double-pole switch connected as single-pole.

as shown at *B*, the length of wire, *D*, may be eliminated. Note that the double-pole switch disconnects only one side of the line from the source of voltage.

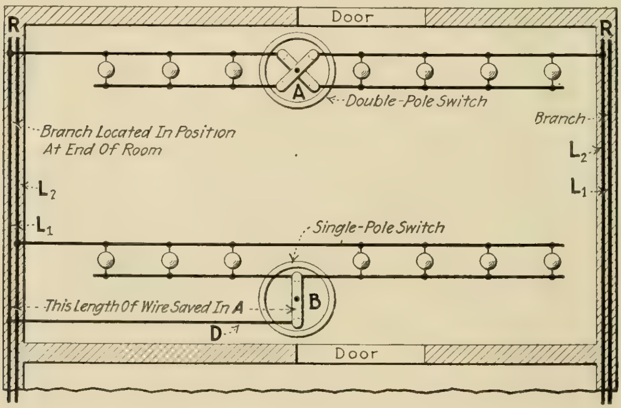


Fig. 199.—Showing how a wire saving may sometimes be effected by using a double-pole switch, *A*, instead of a single-pole switch *B*.

194. A Method Whereby One Double-pole Switch May Be Used For Controlling Two Distinct Circuits is shown in Fig. 200. One of the circuits is completed through one blade of the double-pole switch, *S*. The other circuit is completed through the second blade. The use of a circuit arrangement such as that shown, wherein a low-voltage battery-operated signal circuit is carried into the same double-pole switch with a 110-volt lighting circuit is not sanctioned by the Code (Rule 16*e*

and 85*j*), and will not be approved by inspectors. In Fig. 200, as long as the lamps L are lighted, the vibrating bell, B, will ring. Thus, the bell provides an audible signal of the use of energy by the lamps.

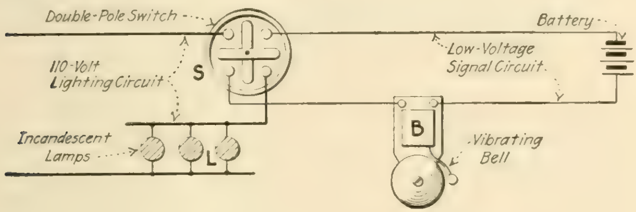


Fig. 200.—One double-pole switch controlling two distinct circuits.

195. Restricted-selective Control May Be Provided By Two Double-pole Switches (Sec. 17) by the connections which are shown in Fig. 201. If both switches, A and C, are open, then lamps A' and B' may be lighted by closing switch A, or lamps B' and C' may be lighted by closing switch C. If both switches are closed; C' may be extinguished by opening C, or, A' may be

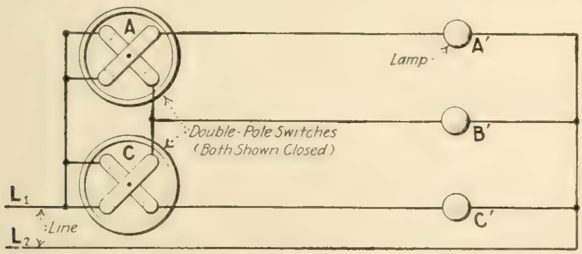


Fig. 201.—Selective control provided by two double-pole switches. (Lights A' and B' may be lighted by closing switch A. Lights B' and C' may be lighted by closing switch C. C and A are respectively extinguished by opening C and A. Both switches must be open to extinguish B'.)

extinguished by opening A. With both switches open, all lights are extinguished; and with both switches closed (as shown in Fig. 201), all lamps are lighted. It is, of course, apparent that a lamp-group comprising a reasonable number of lamps which are connected in parallel may be substituted for either A', B', or C'.

196. Series-parallel, Or "Dimming," Control may be obtained as illustrated in Figs. 202 and 203. When the switch is closed, all lamps have the full line voltage impressed across their terminals. When the switch is open the lamps burn at one-third line voltage, and, consequently, only about one-third of the normal quantity of energy is consumed. The branch-

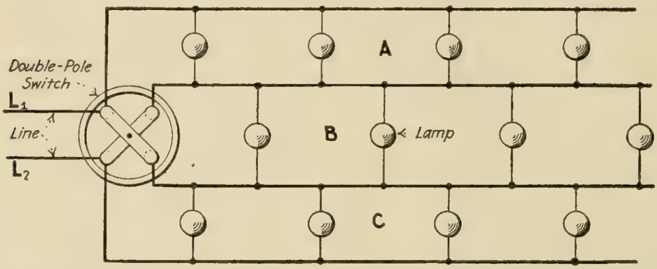


Fig. 202.—Double-pole switch connected to provide series-parallel control for three groups of lamps, *A*, *B* and *C*. (When switch is closed, all lamps have the full line-voltage impressed across their terminals. When switch is open the lamps burn at ⅓ line voltage if groups *A*, *B* and *C*, each contain the same total wattage-rating.)

circuit switch at the distribution center may be used to extinguish all lights. Such an arrangement is particularly applicable in long corridors or hall-ways, in large areas such as machine shops, storage rooms, and the like, where at certain times it is desired to secure a distributed dim light for burglar protection or night-watchman's use, and at other times, to

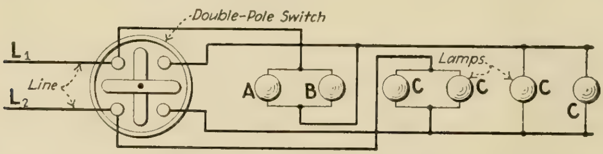


Fig. 203.—Showing how a wire saving may be effected in double-pole-switch connections which provide series-parallel or dimming control.

secure the usual illumination. Where all of the lamps so controlled are located in one row, the arrangement shown in Fig. 203 may effect a wire-saving over that in Fig. 202. If all of the lamps of any one group, either *A*, *B*, or *C*, burn out, all of the lights on the circuit will be extinguished as long as the switch is open. The total wattage of the lamps in each group

(A, B, and C) should be always kept the same. When tungsten lamps burn at one-third normal voltage, the filament is only a dull red.

197. A Wire-saving Method Of Adding A Pilot Lamp Or A Group Of "Night-and-day" Lamps To An Existing Double-pole Switch Installation is outlined in Figs. 204 and 205. In

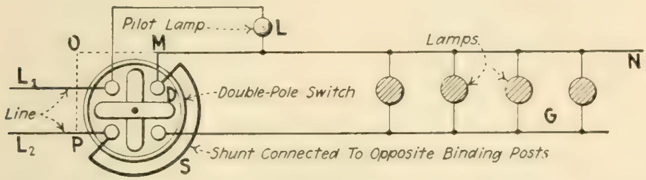


FIG. 204.—Double-pole switch with shunt, S, connected to diagonally-opposite binding-posts. (Lamp L cannot be extinguished by the switch.)

Fig. 204, the pilot lamp, L, completes its circuit through one conductor, MN, of the group of lamps, G. A wire-saving, which is approximately equal to the distance from the switch, D, to the lamp, L, is thereby effected. The shunt, S, which is connected to opposite binding posts of the switch, D, renders it impossible to extinguish L by opening D. Thus, lamps G may be extinguished by opening D, while the pilot

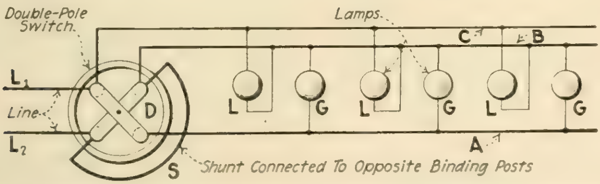


FIG. 205.—Double-pole switch with shunt, S, connected to diagonally opposite binding posts. (Lamps L cannot be disconnected from source of voltage by switch D.)

lamp, L, remains lighted. In Fig. 205, the circuit arrangement is essentially the same as that of Fig. 204. However, in Fig. 205, alternate lamps, L, of the group are constantly connected to the line, L_1L_2. Lamps G (Fig. 205) may, therefore, be extinguished by opening D, while lamps L remain burning. This method is frequently employed where it is desired to subdivide the lamps on a long hall-way circuit so that one-half of the lamps may be lighted during the day, and all of them at

night. All lights are turned out by the branch-circuit switch at the distribution center. It may sometimes be found more convenient to omit the shunt (*S*, Figs. 204 and 205) and make the connections in the manner indicated by the dotted line, *MOP*, Fig. 204.

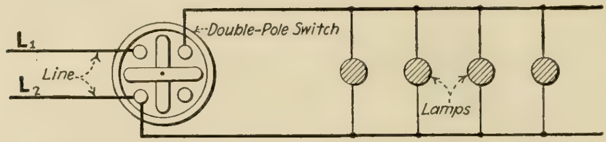


FIG. 206.—Incorrect method of connecting a double-pole switch. (Only one side of the line is disconnected by opening the switch).

198. Some Of The Errors Which Are Likely To Be Made In Connecting Double-pole Switches are illustrated in Figs. 206, 207, and 208. The switch, when connected as in Fig. 206,

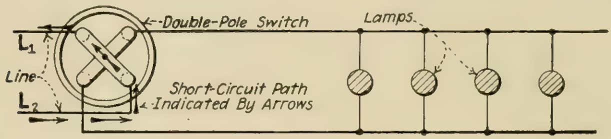


FIG. 207.—Showing incorrect method of connecting a double-pole switch. (Line is short-circuited when switch is closed.)

will operate to open (Sec. 143) only one side of the line. If the connections are made as shown in Figs. 207 and 208, a short-circuit will result upon closing the switch.

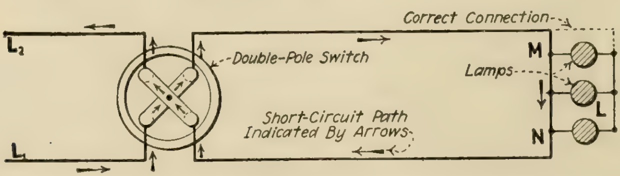


FIG. 208.—Showing incorrect method of connecting a double-pole switch. (Line is short-circuited when switch is closed. The circuit wires have been connected incorrectly at *M* or *N*.)

199. Restricted-selective Control May Be Provided By A Double-pole, Double-throw Switch (Fig. 209). This control arrangement is sometimes called *electrolier control* (Sec. 17). By closing the switch to position A' (Fig. 209), lamps A only

are lighted. If the switch is thrown over and contact made with the opposite pair of jaws, B', all of the lamps, A and B will be lighted. All lights may be extinguished by leaving the switch in the open position—not contacting with either pair of break-jaws. However, it should be noted that when the switch is in the open position, only one side of the line, L_2, is

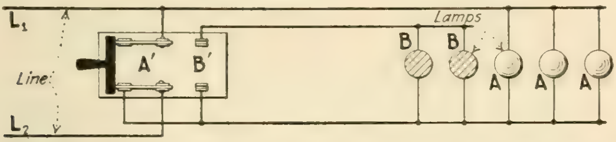


FIG. 209.—Electrolier control provided by double-throw double-pole switch. (By closing switch-blades to position A', lamps A are lighted. All lamps are lighted when switch is closed to position B'.)

disconnected from the lamps. Even when the switch is open, lamp-group A connects directly to line L_1, and lamp-group B connects to L_1 through group A.

200. A Double-pole, Double-throw Switch May Be Used To So Control Two Groups Of Lamps That Only One Group Can Be Lighted At A Time (Figs. 210 and 211). In Fig. 210, lamps A are lighted and lamps B extinguished by closing the

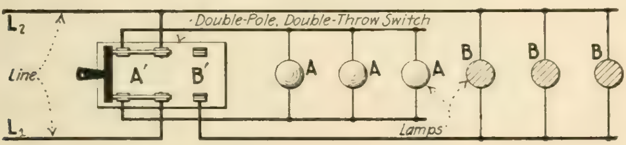


FIG. 210.—Double-pole double-throw switch connected for restricted lighting circuit. (Only one group of lamps can be lighted at a time. With switch-blades in position A', lamps A are lighted. Lamps B are lighted and lamps A are extinguished when blades are closed to position B'.)

switch to position A'; lamps B are lighted and A extinguished by closing the switch to position B'. When the switch is either open, or closed to B', lamps A are completely isolated from the line, L_1L_2, and are, therefore cut "dead." However, only one side of the line—side L_1—can be disconnected from group B; the other side of B is permanently connected to L_2. Four wires are required in the run between the switch and the lamps. In Fig. 211, the same control is provided as

that in Fig. 210. However, it should be noted that in Fig. 211 only three wires are required from the switch to the lamps; also that only one side of the line—side L_1—can be disconnected from either lamp *A* or *B*.

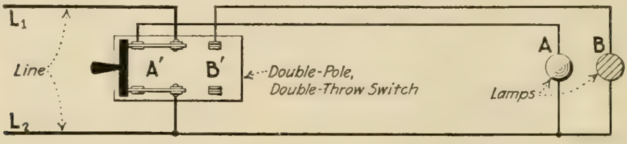


Fig. 211.—Restricted lighting circuit controlled by double-pole, double-throw switch, requiring only three wires from switch to lamps. (Blades closed to position *A′* lights lamp *A*. Blades closed to position *B′* lights lamp *B*. Blades in the open position, all lamps off.)

201. Double-pole, Double-throw Switch Connections for Restricted-selective Control of 110-volt Lamps On A 220-volt Circuit are shown in Fig. 212. As connected, only two lamps can be lighted at a time: With the switch closed to *A′*, lamps *C* and *E* are lighted, and lamp *D* is extinguished; by closing the switch to the other side, *B′*, lamps *D* and *E* are lighted and *C* is extinguished. By permitting the switch to remain in the open position both sides of the line (L_1 and L_2) are disconnected from the lamp-circuit. This method of connection is particularly well adapted for use in industrial plants where restricted-selective (Sec. 17) control of 110-volt lamps on a 220-volt motor circuit is desired. If the line, L_1L_2, is connected to a 110-volt supply, the lamps will—if they are 110-volt lamps—burn at only one-half normal voltage. The lamps—or lamp-groups—*C*, *D*, and *E*, must each be of the same wattage rating if they are expected to burn at normal candlepower when the switch is closed.

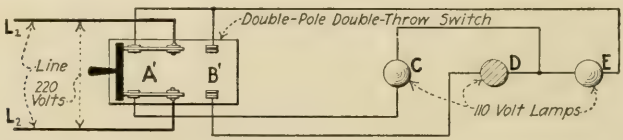


Fig. 212.—Double-pole double-throw switch connections for operating two incandescent lamps in series, so arranged that only two lamps can be lighted at a time. (Switch-position *A′*, lamps *C* and *E* lighted; switch-position *B′*, lamps *D* and *E* lighted.)

202. Lamps May Be Connected Either In Series Or In Parallel By The Operation Of A Double-throw, Double-pole Switch as shown in Figs. 213 and 214. In Fig. 213-*I* and *II*, the two lamps are in series when the switch is closed to position *S*, and in parallel when closed to *P*. When the switch is

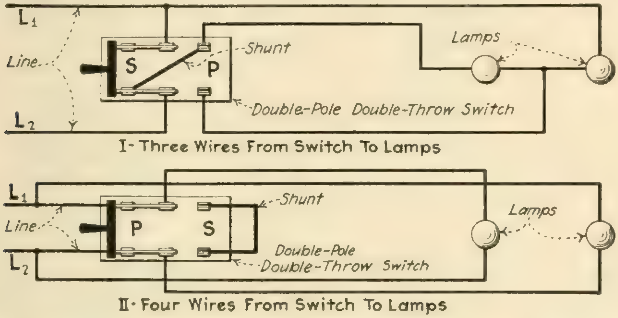


FIG. 213.—Series-parallel connections for a double-pole double-throw switch. (Lamp are in series when switch is closed to *S*, and in parallel when closed to position *P*.)

open, both lamps are extinguished. The switch, when it is open, disconnects only one side of the line from the lamp circuit. In Fig. 213-*II*, four conductors are required between the lamps and the switch, whereas in Fig. 213-*I*, only three are used. The three groups of lamps (Fig. 214) are controlled as

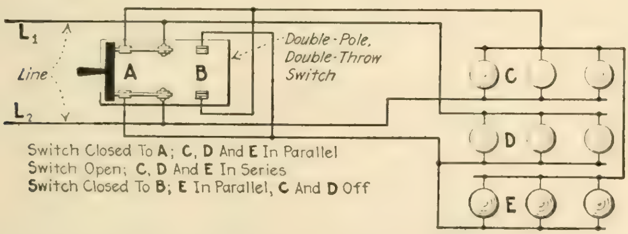


FIG. 214.—Double-pole double-throw switch providing parallel and series control for three groups of lamps.

follows: (1) *Switch closed to A*, groups *C*, *D*, and *E*—in parallel—operate at full line voltage. (3) *Switch closed to B*, *C* and *D* extinguished, and *E*—across the line—operates at full voltage. (3) *Switch open*, groups *C*, *D*, and *E*—in series—operate at one-third line voltage. Although such connections are particularly adapted to heating units, they may be employed

in lighting where dimming is desired. The statements just preceding as to the voltages impressed on the lamp-groups assume that the total wattage rating is the same for each of the three lamp-groups.

203. A Group Of Lamps May Be Controlled From Two Locations By Two Double-pole, Double-throw Switches

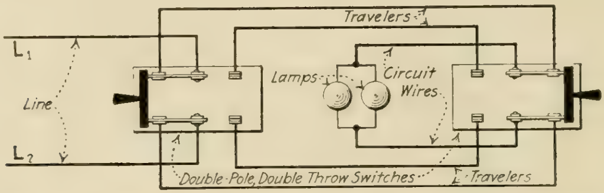


FIG. 215.—Two-location control provided by two double-pole double-throw knife switches. (Neither switch should ever be left open, but always closed to one or the other set of jaws.)

by arranging the connections as shown in Fig. 215. After the lamps have been extinguished, by means of either switch,

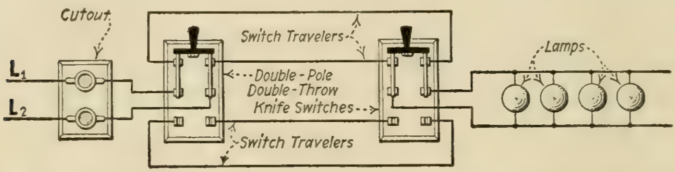


FIG. 216.—Two vertically-mounted double-pole double-throw knife switches for two-location control.

the switch must not be left in the open position, but must be closed to the opposite side. If one switch is left in the open

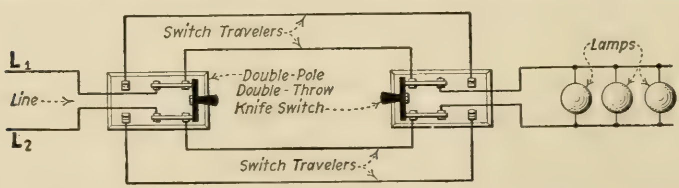


FIG. 217.—Two horizontally-mounted double-pole double-throw knife switches for two-location control.

position, the lamps cannot be lighted by closing the other switch. Figures 216 and 217 show other arrangements of the same circuit.

204. Three-location Control May Be Obtained With Two Single-pole, Double-throw Switches And One Double-pole,

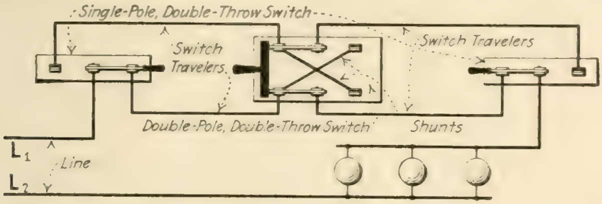


FIG. 218.—Three-location control provided by knife switches. (Shunt connected within the switch.)

Double-throw Switch (Figs. 218 and 219). As in Sec. 203, all switches must, to provide effective three-location control,

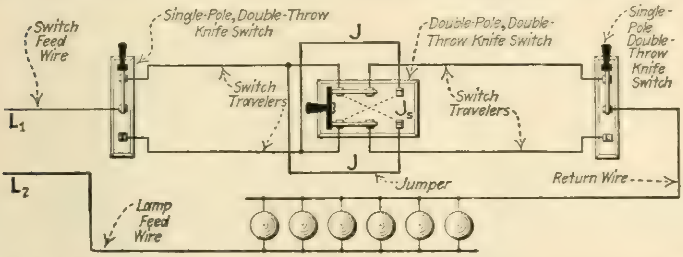


FIG. 219.—Three-location control with knife switches (shunt or jumper outside of switch).

always after operating be left in the closed position. As many other locations of control as are desired may be pro-

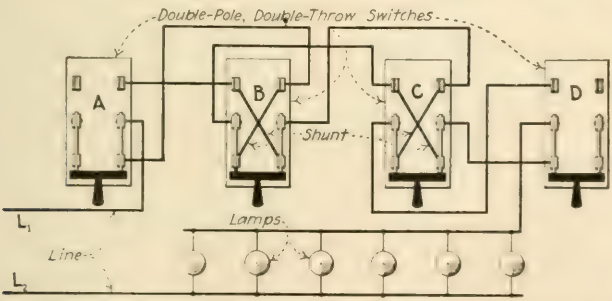


FIG. 220.—Control from four locations with double-pole, double-throw switches. (Switches *A* and *D* may, if desired, be single-pole double-throw.)

vided by connecting (*B* and *C*, Fig. 220), for each additional location, a double-pole, double-throw switch into the circuit.

Note.—Multi-location Control May Be Obtained By Using Only Double-pole, Double-throw Switches (Fig. 220). Only one side of the end-switches (A and D, Fig. 220) is employed, and the intermediate switches (B and C) are connected as shown.

205. A Double-pole, Double-throw Switch May Be Used To Assist in Balancing The Load On A Three-wire-neutral

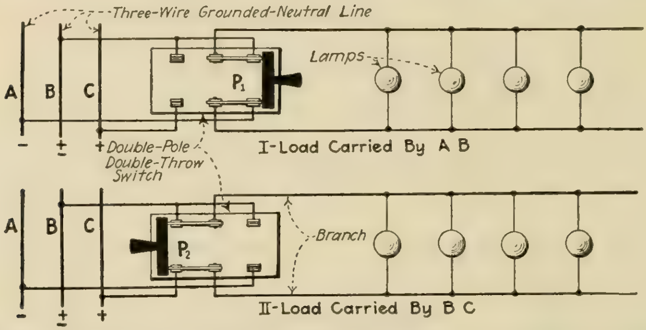


Fig. 221.—Method of making balancing-switch connections for balancing the load on a three-wire-neutral system.

System (Fig. 221). With the switch closed to position P_1, the branch-circuit load will be carried by conductors AB. By throwing the switch over to position P_2, the load will be carried by BC. By thus connecting all or certain of the mains or branches to the feeders, the lighting load of a large building may be so shifted as to minimize the current which flows through the neutral, B.

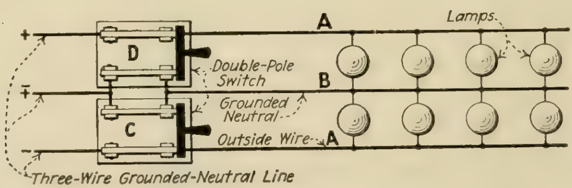


Fig. 222.—Diagrams of connections showing two double-pole switches so arranged that either outside wire may be opened independently of the other, but the neutral cannot be opened without opening both outside wires.

206. Two Double-pole Switches May Be Used For The Service Switch Of A Three-wire-neutral System. To comply with Code Rule 24a, Par. 5 (Sec. 137) they must be so connected (Fig. 222) that either outside wire, A, may be

opened independently of the other, and, that the neutral, B, cannot be opened without—at the same time—opening both outside wires. By opening either switch, C or D, independently of the other, one outside wire is opened. When both switches are open, both of the outside wires, A, and also the neutral, B, are disconnected from the line.

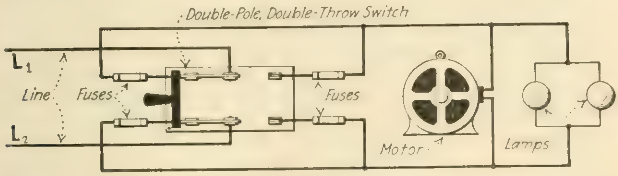


Fig. 223.—Double fuse connections for combined lighting and power circuit controlled by double-pole double-throw switch.

207. A Double-pole, Double-throw Switch Having A Double Fuse Connection (Fig. 223) may be effectively used for connecting a combined lighting-and-motor circuit to the line. This is desirable in certain installations where the motors may frequently be subjected to large overloads, and where continuity of lighting service is of greater importance than is that of the motor service. When an accidental motor overload ruptures a fuse, the double-throw switch may be closed to the opposite set of jaws, thus immediately relighting the lamps. The cause of the trouble may then be found and removed and the motor started; after which, the fuse replacement can be made.

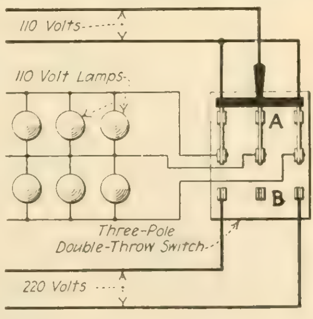


Fig. 224.—Schematic diagram, showing how 110-volt lamps may be connected through a three-pole, double-throw switch to operate at full candle-power—normal voltage—from either 110 or 220 volts. (Switch closed to A, lamps are lighted from 110-volt supply; closed to B, lamps are lighted from 220-volt supply.)

208. A Three-pole, Double-throw Switch May Be Used To Operate 110-volt Lamps From Either A 110-volt Supply Or A 220-volt Supply (Fig. 224). A switch so used is sometimes called a *throw-over switch*, or *transfer switch*. When the switch is in position A, all of the lamps are connected, in parallel,

to the 110-volt supply, and when it is in position *B*, they are connected, in series-parallel, to the 220-volt supply. Thus the lamps may be operated at normal voltage from either the

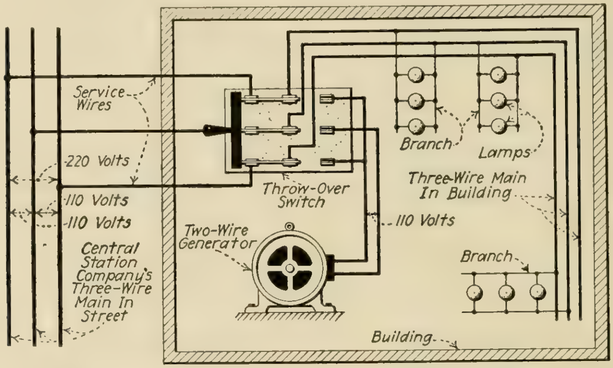


FIG. 225.—Schematic diagram of connections for throw-over-switch installation for a two-wire interior system and three-wire street mains. (Service-entrance overload-protective equipment and other details not shown.)

110-volt or the 220-volt supply. In those industrial plants where the energy for the motors is supplied at 220 volts, and

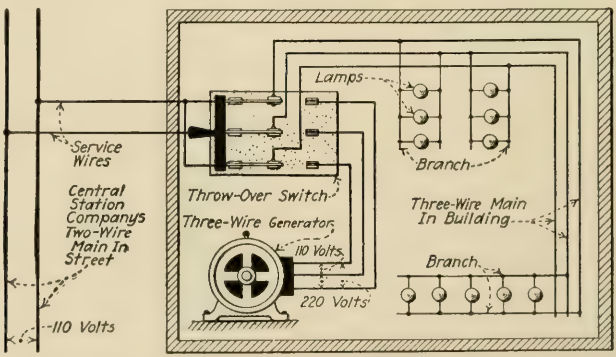


FIG. 226.—Schematic diagram of connections for throw-over-switch installation for three-wire interior system and two-wire street mains. (Over-load-protective equipment and other details not shown.)

that for lighting at 110 volts, such a transfer switch is exceedingly convenient for emergencies. Thus, when trouble occurs on the lighting circuit, the lighting load may be transferred

to the motor circuit and so carried until the lighting circuit is repaired.

NOTE.—A THROW-OVER SWITCH MAY BE USED IN THE SERVICE TO A BUILDING WHICH MAY BE FED BY EITHER A THREE-WIRE OR A TWO-WIRE SYSTEM (Figs. 225 and 226). Thus, in office buildings, energy is frequently generated at 110 volts, two-wire, and the street mains of the central-station company are 110–220 volts, three-wire, or vice versa. With a switch arranged as in Figs. 225 or 226, the load in the building may be readily shifted from one system to the other. Where either of these arrangements are employed, the cross-sectional area of the three-wire-system neutral which is within the building must be twice as great as the cross-sectional area of either of its outside wires.

209. A Three-pole Double-throw Switch Arranged To Connect Two Lamp-groups In Either Parallel Or Series-parallel is shown in Fig. 227. When the lamps are, as in *II*,

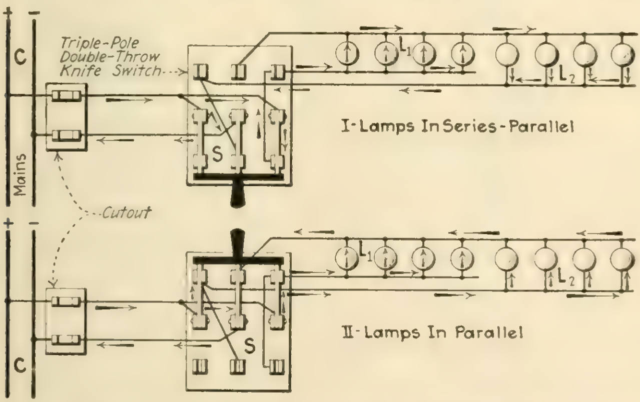


FIG. 227.—Three-pole double-throw switch wired to connect lamp groups in either parallel or series-parallel. (The arrows indicate the directions of current when the polarities are as shown at the left.)

connected in parallel, then both lamp-groups, L_1 and L_2, have impressed across them the voltage of the supply circuit, C. But when S is thrown to the position of I, the lamps, now connected in series-parallel, have impressed across them only half the supply-circuit voltage—assuming that the total wattage of L_1 is the same as that of L_2. With only half supply-circuit voltage across the lamps, their candle power is considerably decreased. Hence this may be used as a *dimmer*

circuit. For satisfactory operation, both of the lamp-groups must be of the same total wattage.

210. The Wiring For A 120-volt Extension Lamp In A 600-volt Parallel-series Circuit may be connected as indicated in Fig. 228. The stationary outlets, 1 to 5, are so arranged that five lamps are in series across 600 volts. One outlet, *E*, is arranged to serve the portable extension lamp. For each portable-extension outlet, a duplicate receptacle is shunted in parallel with one a stationary outlet, *L*, of the parallel-series circuit. To connect an extension lamp it is only necessary to plug into the extension receptacle, *E*, and then to

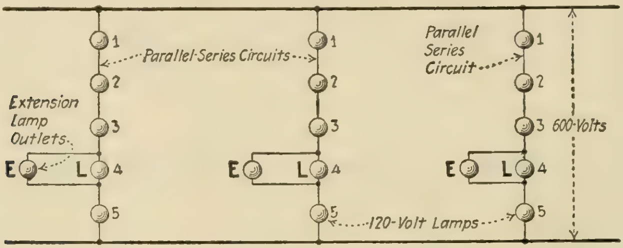


FIG. 228.—Wiring for 120-volt extension lamp in a 600-volt parallel series circuit. Lamps *E* and *L* should not be "on" simultaneously any longer than necessary.

unscrew or switch off the lamp which is in *L*. When the extension-circuit plug is to be removed from *E*, the dead lamp in *L* must first be screwed or switched into the circuit, otherwise a dangerous arc may be drawn in the receptacle.

211. One Lamp Of A Four-lamp Fixture May Be Lighted From A Three-wire System as indicated in Fig. 229. The method shown was employed by the *Kansas City Electric Light Company* for supplying energy to the four lamps on each street fixture. With this method, one lamp on each fixture may be operated all night and still, when all of the lamps are lighted, the advantages of a three-wire system, is retained.

EXPLANATION.—At the 2,200-volt distributing board in the central station are a double-pole oil switch, *A*, (Fig. 229) and a single-pole oil switch, *B*, connected as shown. Up to midnight both of these switches, *A* and *B*, are closed; after that time, the single-pole switch is opened, thereby leaving a single night lamp on each post in service until sunrise. Two single-phase transformers, *C* and *D*, are used for each section. One transformer, *D*, furnishes the energy for the lamps which are lighted

until midnight (with the exception of the all-night lamps); the other transformer, *C*, furnishes energy for the all-night lamps only. A wire, *W*, connects the middle points of each secondary and is grounded, in addition being connected to one of the lines running along the top of each pole. By connecting the outer wires to the transformers as shown, 220 volts is maintained across them and the advantages of a three-wire system are thus obtained. The neutral wires, *T*, on each side of the street are, where practicable, "tied" together with tie wires *R*.

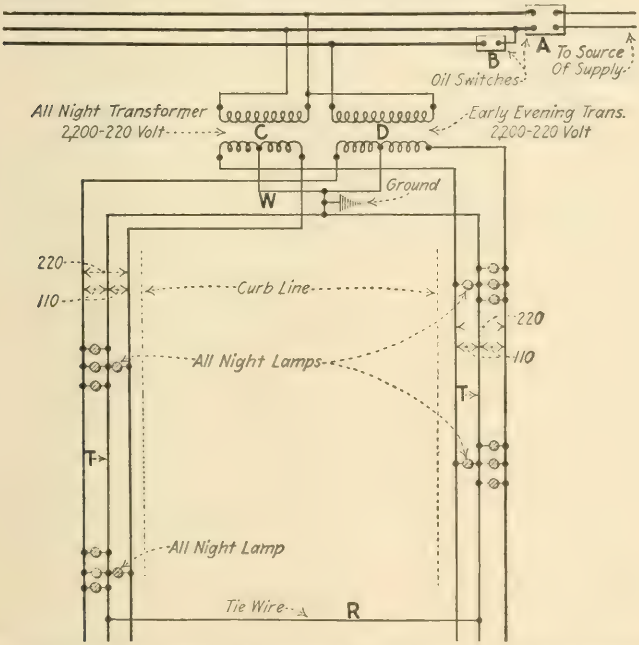


Fig 229.—Lighting one lamp of a four-lamp fixture from a three-wire single-phase system.

QUESTIONS ON DIVISION 4

Make a diagram of connections and explain the operation of, and the lamp control, which is provided by the following:

1. Two single-pole switches connected in series.

2. Two single-pole switches connected in parallel.

3. Two single-pole switches controlling two groups of lamps using a common return.

4. Two single-pole switches connected to provide restricted-selective control for a single group of lamps.

5. A single-pole, double-throw switch for dimming.

6. A single-pole, double-throw switch controlling two groups of lamps so that only one group can be lighted at a time (restricted control).

7. A single-pole, double-throw switch for balancing the load on a three-wire (not three-phase) system.

8. Two single-pole, double-throw switches for load-balancing on a three-phase system.

9. Two-location control with two single-pole double-throw switches.

10. Two double-pole switches connected in parallel. In series.

11. Series-parallel connection of double-pole switches.

12. Double-pole switch connected as single-pole.

13. Two double-pole switches providing restricted-selective control for three groups of lamps.

14. One double-pole switch for dimming to one-third normal voltage.

15. Common errors in connecting double-pole snap switches.

16. One double-pole, double-throw switch for: (*a*) *Restricted-selective control.* (*b*) *Restricted control.* (*c*) *Restricted-selective control of three* 110-*volt lamps on a* 220-*volt circuit.* (*d*) *Series to parallel and parallel to series.*

17. Two-location control by two double-pole, double-throw switches.

18. Three-location control by two single-pole, double-throw switches and one double-throw, double-pole switch.

19. Multi-location control with double-throw, double-pole switches.

20. Double-pole, double-throw switch for load balancing on a three-wire-neutral system.

21. Two double-pole switches used as a service switch.

22. Three-pole, double-throw switch for throw-over from 110- to 220-volt supply.

23. Throw-over switch for building-service connection which will permit of either two-wire or three-wire operation within the building.

DIVISION 5

THREE- AND FOUR-WAY SWITCH CIRCUITS

212. The Application Of Three-way And Four-way Switches Offers A Wide Range Of Combinations for multiple-location control of interior wiring lighting circuits. A single lamp or a group of lamps may be so arranged, in relation to two three-way switches, that the lamp or lamps can be lighted or extinguished by either of the switches independently of the other. If additional control locations are desired, four-way switches may, as will be described later, be added to the circuit to provide the additional control locations. The wiring connections and diagrams for these various switch circuits will be considered in the following sections.

NOTE.—THERE ARE REALLY TWO DISTINCT SYSTEMS OF CONNECTING THREE-WAY AND FOUR-WAY SWITCHES: (1) THE "STANDARD" SYSTEM (2) THE "CARTER" SYSTEM; (see Fig. 283). The standard-system methods are first discussed and then the Carter system is described (Sec. 249) and its advantages and disadvantages explained.

213. Three-way And Four-way Switches May Be Utilized As Single-pole Switches if connected in a lighting circuit, as

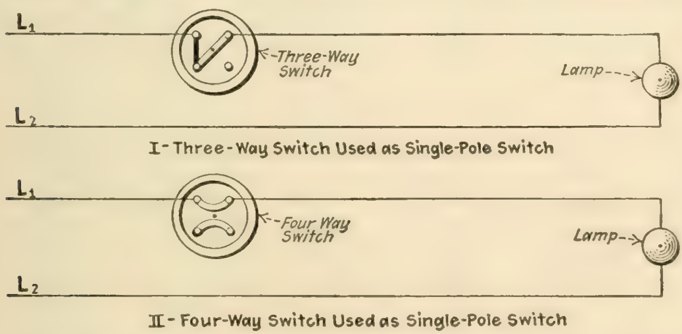


FIG. 230.—Three- and four-way switches used as single-pole switches.

shown in Fig. 230-*I* and *II*. These methods, of course, provide only one control location on the lighting circuit in which they are installed. While the usage of Fig. 230 is uneconomical, it

may, in emergencies, be employed when single-pole switches are not available.

214. Diagrams For Simple Or Elementary Three-way Switch Circuits For The Control Of The Circuits From Two

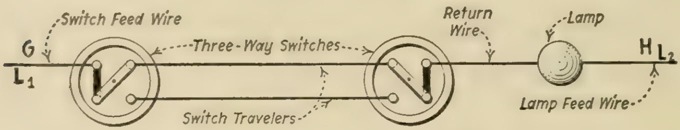


FIG. 231.—Simple three-way switch circuit feeding from each end.

Locations are shown for surface snap switches in Figs. 231, 232, 233, and 234. Figure 234 is a phantom view showing the actual connections of the switches for such service, while

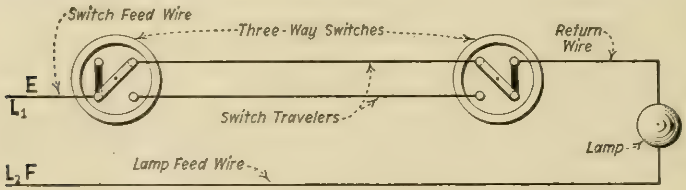


FIG. 232.—Three-way switch circuit feeding from one end only.

Figs. 231 and 232 are diagrammatic representations. From the connections of these two illustrations it is evident that at no time, either one of the switches being open, are both polari-

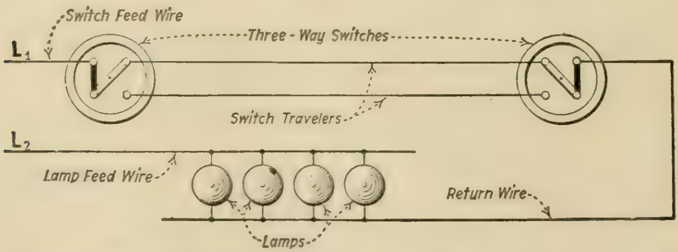


FIG. 233.—Three-way switch circuit feeding from one end, for control of several lamps.

ties of the feeding circuit present in either switch. This feature renders a connection of this type strictly in compliance with wiring rules which are enforced in certain cities and which

are based on CODE Rule 24c. (See Secs. 144 and 251.) Figure 235 shows the connections where flush, push-button switches are used.

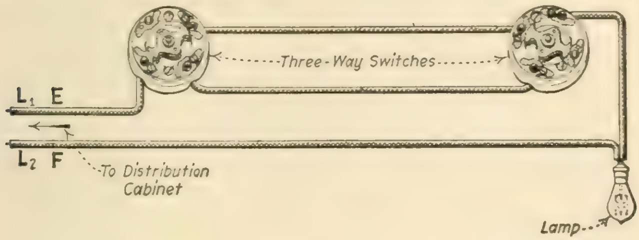


FIG. 234.—Phantom diagram of a three-way switch circuit.

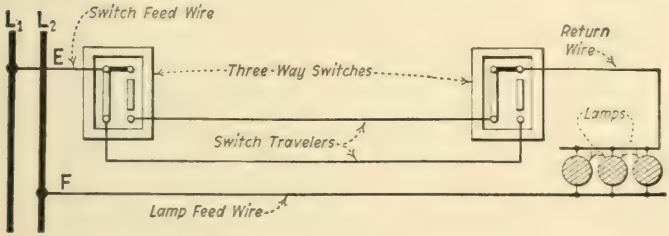


FIG. 235.—Wiring diagram for three-way flush push-button switch circuit.

215. A Three-way Switch Circuit Which Is Fed From Different Branches is outlined in Fig. 236. It will be noted that this connection is essentially the same as the connections of Figs. 231 and 234 with the exception that the feed wires

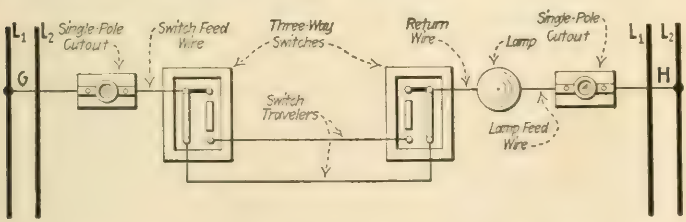


FIG. 236.—Three-way switch circuit feeding from two different branches.

approach the switch-and-lamp circuit from opposite sides and feed from different branch circuits. In making the connections of Fig. 236 it is imperative that proper care be taken to insure that the wires of correct polarities enter the switch-and-

lamp circuit from each of the branch circuits, G and H. Otherwise the system would be inoperative. Wherever this system is utilized, the switch feed and the lamp feed wires should each be protected by its own single-pole cutout.

Note.—Serving A Three-way Switch Circuit From Two Different Branch Circuits As In Fig. 236 Is Not Recommended because of complications which may develop when trouble occurs in the circuit. It is, however, sometimes advisable when wiring finished buildings so that the taking up of extra flooring may be avoided, and for other possible economic reasons, to install a three-way switch circuit as shown in Fig. 236.

216. The Wiring For A Three-way Switch Circuit Which May Be Used When The Switches Are Located Near Each

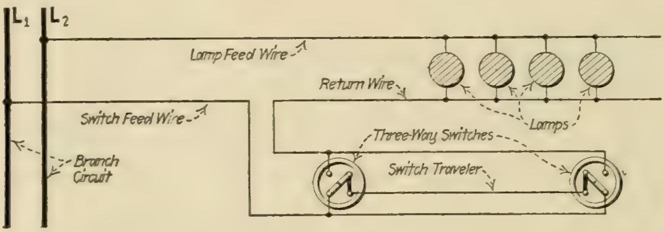


Fig. 237.—Three-way switch circuit for switches located near each other. Only one polarity in either switch.

Other is illustrated in Fig. 237. This is an adaptation of the "Carter" system of wiring which is described more in detail in Sec. 249. As will be noted, this provides a convenient arrangement in the circuit lay-out.

217. Incorrect Three-way Switch Circuit-connections are sometimes made in an installation, especially where the locations at which the lamp feed wire and the switch feed wire are tapped into the branch circuit, are spaced a considerable distance apart. The reason for this is that a wireman may, under these conditions, have difficulty in tracing out the branch circuit.

Example.—Such an incorrect connection is shown in the diagram of Fig. 238 where C and D are both connected to wires of the same polarity. When a three-way switch installation is made as shown in this illustration it is said to be "*off circuit*" and, obviously, will not operate. The most effective way of correcting such a difficulty, especially after the

job has been completed, is to reverse the connections at the branch block, either at *A* or at *B*, Fig. 238.

NOTE.—THREE-WAY AND FOUR-WAY SWITCHES ARE FREQUENTLY MISTAKEN FOR DOUBLE-POLE SWITCHES. This is because of the similarity in external appearance. Some of the errors in connection due to such

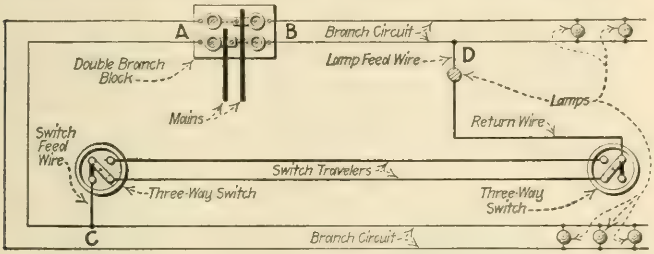


FIG. 238.—Showing three-way switches with lamp- and switch-feed wires improperly connected to the same side (polarity) of the branch circuits.

a mistake are shown in Fig. 239. A three-way switch connected as a double-pole switch (Fig. 239-*I*) will not light the lamp. At *II*, is shown a four-way switch connected as a double-pole switch. Lamps will be lighted when in position *A*, but when the switch is operated to position *B*, the line will be short circuited. At *III*, if the usual connections for a four-way switch are employed in an attempt to secure double-pole operation, the lamps cannot be turned out by the switch.

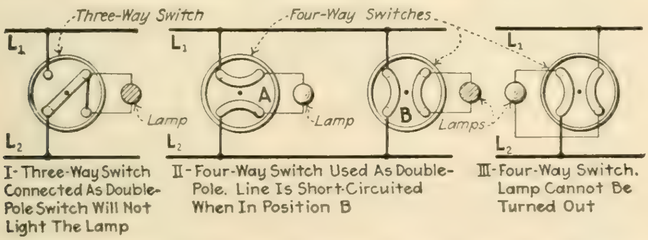


FIG. 239.—Common errors in the connection of three- and four-way switches.

218. A Wiring Lay-out For A Two-story-and-attic Cottage In Which A Three-way Switch Circuit Is Incorporated for the simultaneous control of both an upstairs and a downstairs hall light is shown in the sectional view of Fig. 240. This lay-out is probably typical of the average small-residence three-way switch circuit connection.

NOTE.—THE SWITCH FEED WIRE ON THE FIRST STORY is taken from a "jumper" wire, *J*, from the single-pole switch-feed wire directly to the left. This construction is much more economical than that involved

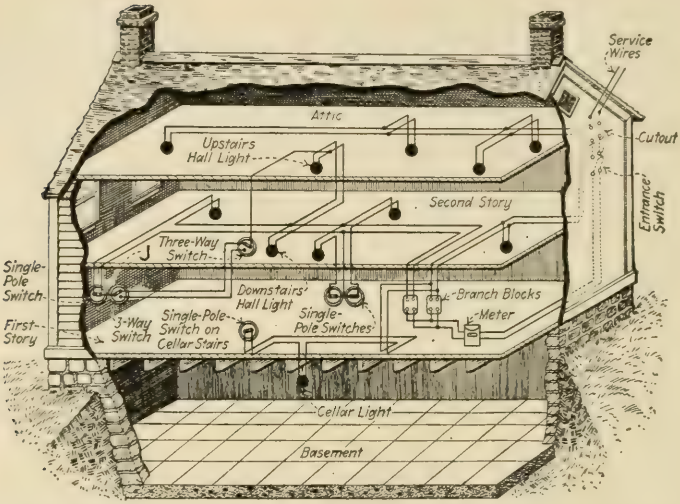


FIG. 240.—Schematic diagram showing wiring in a cottage showing three-way switch circuit for control of hall lights.

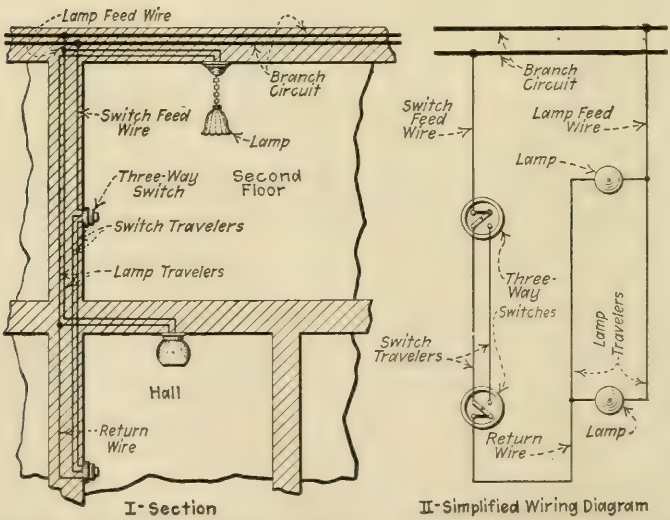


FIG. 241.—Lay-out and connection diagram for a residence three-way switch circuit.

when a special feed is run to the three-way switch. Other typical installations are illustrated in the sectional drawings of Figs. 241, 242, 243 and 244.

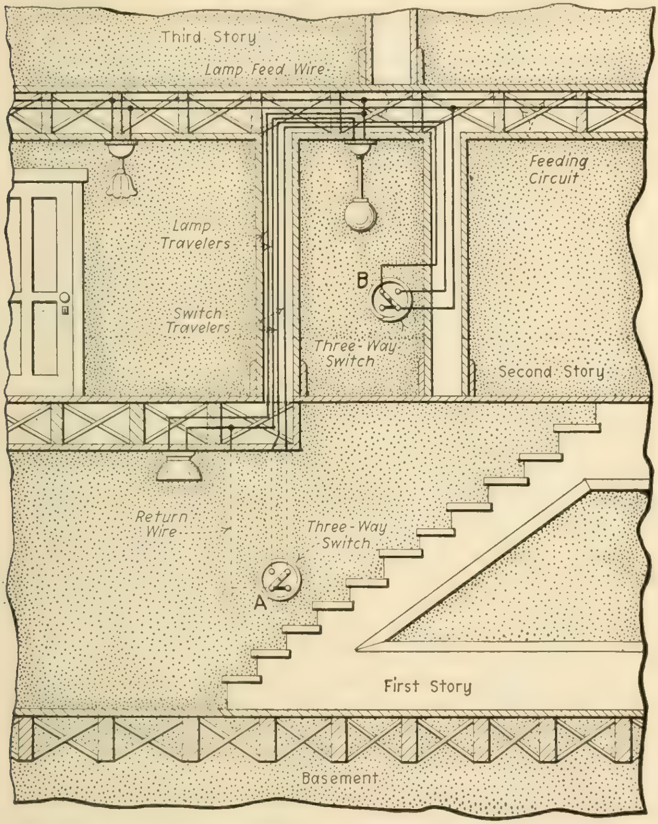


FIG. 242.—First and second story hall lights controlled by two three-way switches *A* and *B*.

219. A Rather Unusual Case Of Three-way Switch Wiring is illustrated in Fig. 245. It was necessary in this building to so wire the hall-light circuits that they could be controlled from two locations by three-way switches and that the hall-light energy could be metered separately from the energy used by the tenants of the first and second stories. In other words, the owner desired to pay for the hall-lighting energy and

wished each tenant to pay for the energy he used on his own floor. An arrangement was effected with the central station whereby the hall lighting was furnished at a flat rate, elimi-

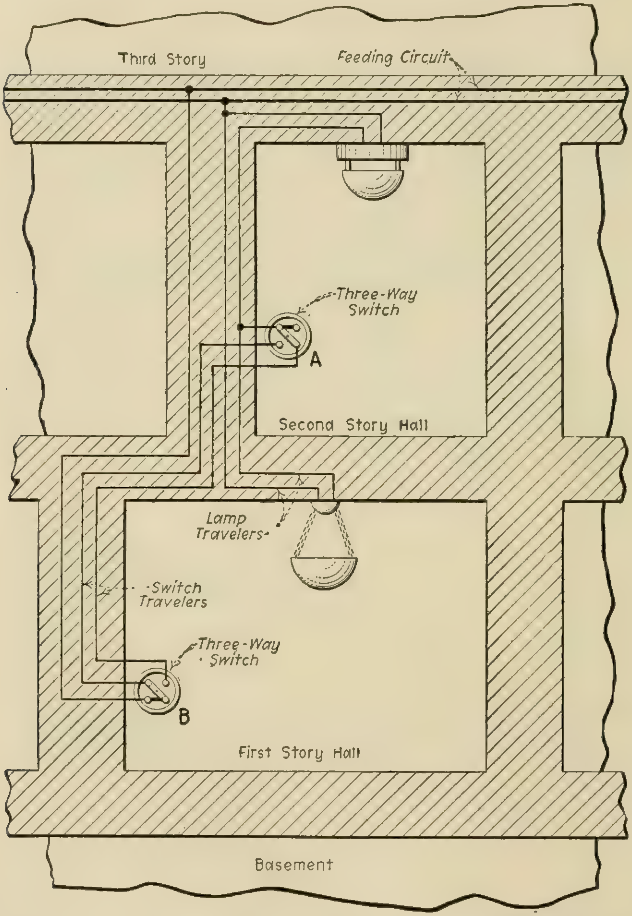


FIG. 243.—Hall-lighting three-way circuit fed from space between second and third stories. (Three-way switches at *A* and *B*.)

nating the necessity of a meter for this portion of the load. This condition very materially simplified the problem, inasmuch as it was then only necessary to so connect the meter series coils in the branch circuits that the hall lighting current would

not feed through them. If the circuits of Fig. 245 are traced out it will be evident that the energy for the hall lights does not pass through any meter.

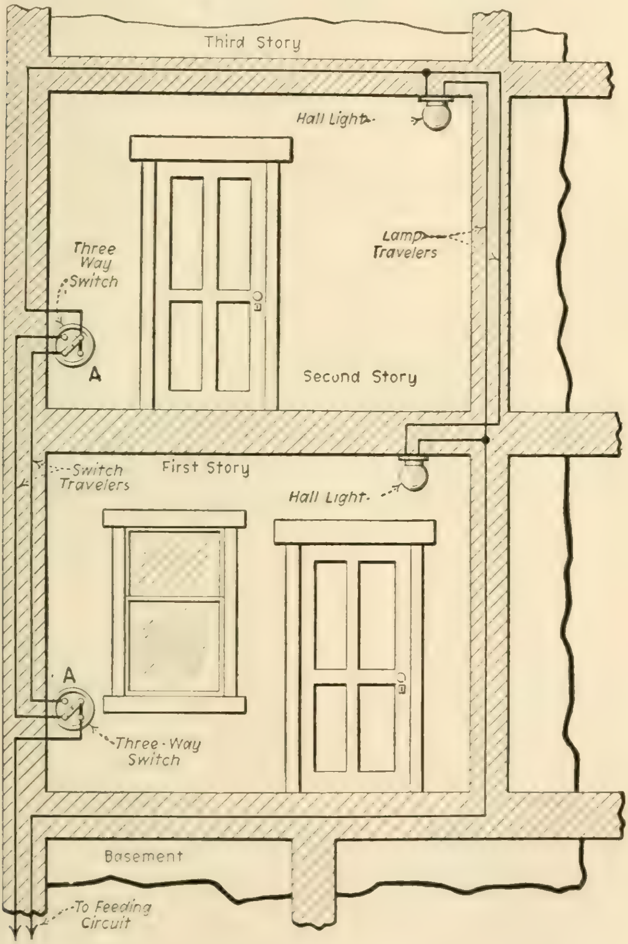


FIG. 244.—Three-way switch circuit feeding from below.

220. Two-location Control Of A Lighting Circuit May Be Effected By The Use Of Four-way Switches (as illustrated in Fig. 246) instead of three-way switches, if the switch travelers are connected to diagonal binding posts within the switches.

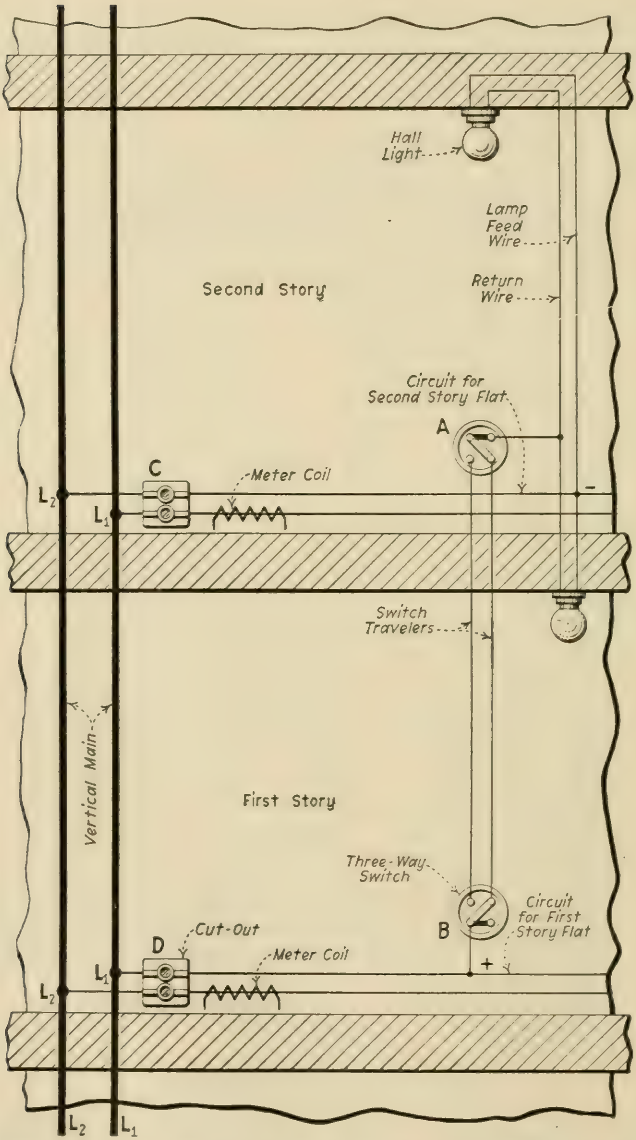


FIG. 245.—Wiring for flat-rate hall lights. (Most electric lighting companies will not sell energy at a flat rate. Furthermore, standard practice is always to connect the current coil of the meter in the "hot" side.,

This illustration is self-explanatory. While the system shown is not to be recommended generally, because it involves a greater first cost than does the usual three-way switch installation, it is sometimes necessary to use four-way switches as shown when three-way switches are not available.

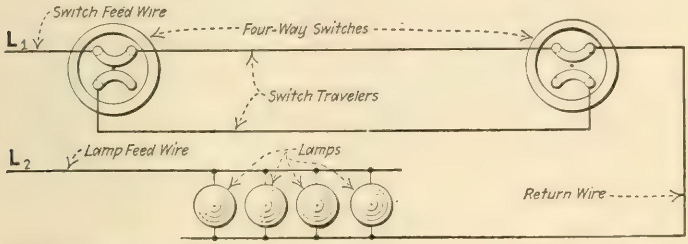


FIG. 246.—Two-location control of a lighting circuit using four-way switches.

221. A Three-way Switch And A Four-way Switch May Be Used In Combination To Afford A Two-location Control of a lighting circuit. The wiring diagram for such a connection is shown in Fig. 247. From a study of this it will be apparent that it is an adaptation of the wiring schemes shown in Figs. 231 and 246.

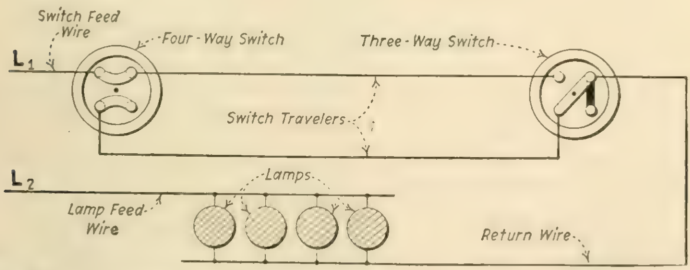


FIG. 247.—A three-way and a four-way switch used in combination for a two-location control.

222. Single-pole Double-throw Knife Switches May Be Used In Combination With Either Three-way Or Four-way Switches to provide control of a lighting circuit from two different locations, as illustrated in Figs. 248 and 249. Neither of these groupings is as economical as that of Fig. 231. They

are used for unusual conditions or in emergencies when standard three-way switches are not available.

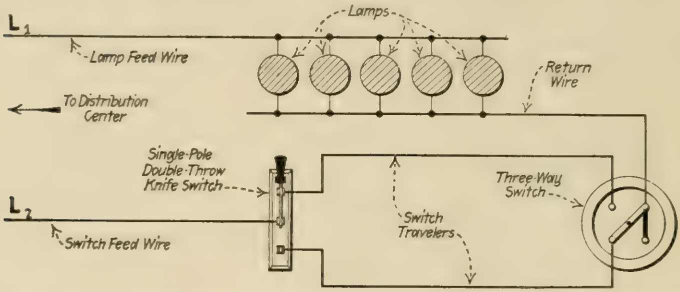


Fig. 248.—Two-location control using one single-pole, double-throw knife switch and one three-way switch.

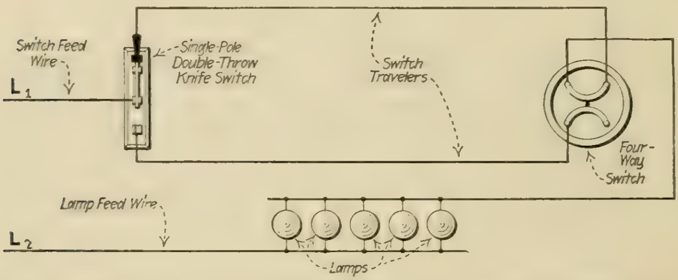


Fig. 249.—Single-pole, double-throw knife switch used in combination with a four-way switch for two-location control.

223. Pilot Or Indicating Lamps On Three-way Switch Circuits (Fig. 250) indicate whether the lamps in the lighting circuit are "on" or "off." They are especially valuable when installed at three-way switch locations from which the lamps in the circuit are not visible. In Fig. 250 the bull's-eye receptacles are merely wired in parallel with the other lamps in the circuit. Hence, they are lighted or extinguished simultaneously with the regular circuit lamps.

225. Control Of A Lighting Circuit From Three Or More Locations May Be Effected By The Use Of Four-way Switches Connected In The Circuit Between The Three-way Switches, as illustrated in Figs. 251, 252, and 253, and 254. These show typical diagrams of the standard method of wiring when it is desirable to provide more than two control locations and are

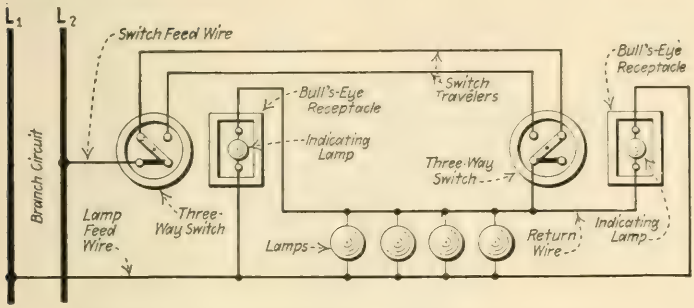


FIG. 250.—Pilot or indicating-lamps in three-way switch circuit.

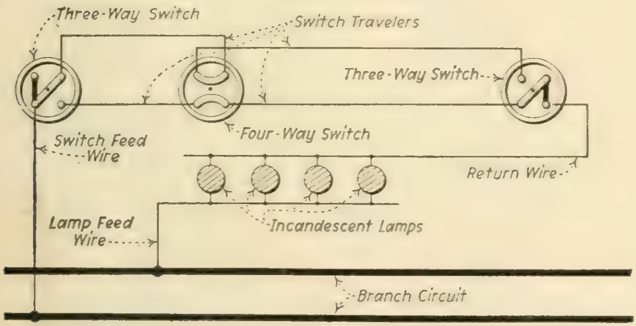


FIG. 251.—Three-location control utilizing two three-way switches and one four-way switch.

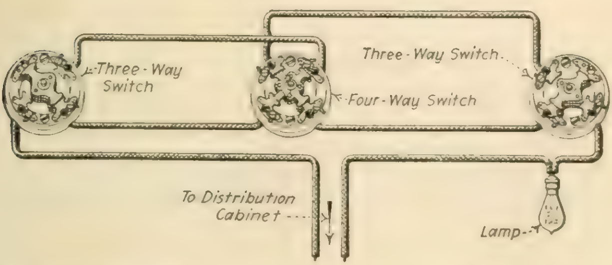


FIG. 252.—Showing how the conductors are actually connected in the three-way and four-way switch for three-location control.

the methods which are used most frequently. Any reasonable number of control locations may be provided by the installa-

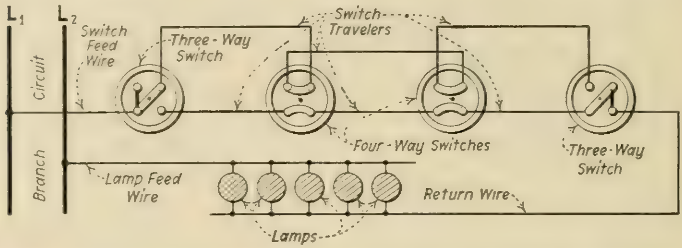


FIG. 253.—A four-location control utilizing two three-way and two four-way switches.

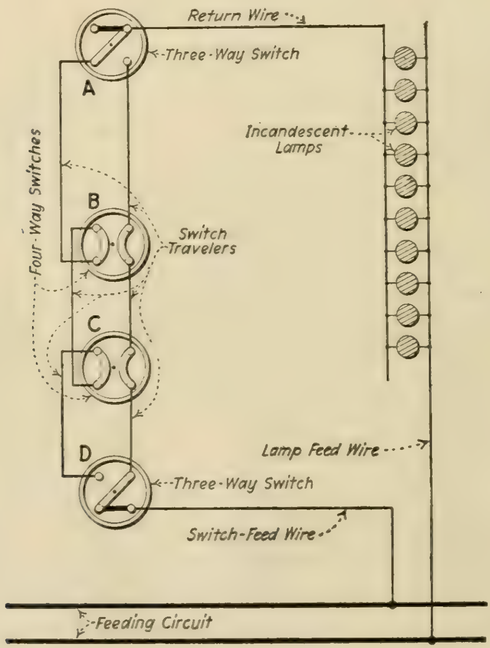


FIG. 254.—Another lay-out for a four-location-control circuit using three-way and four-way switches.

tion of additional four-way switches. One additional four-way switch is required for each additional control location desired.

226. An Installation Providing Four Control Locations, (Fig. 255) A, B, C, and D for the downstairs hall light, L_1, and the upstairs light, L_2, in a two-story residence is encountered frequently. These lights, L_1 and L_2, can be controlled from both the front, A, and rear hall, D, on the first story as well as from the front, B, and rear, C, of the second-story hall. Three-way switches, A and D, provide the control in the first story while that in the second story is furnished by four-way switches, B and C, located as shown. Figure 256

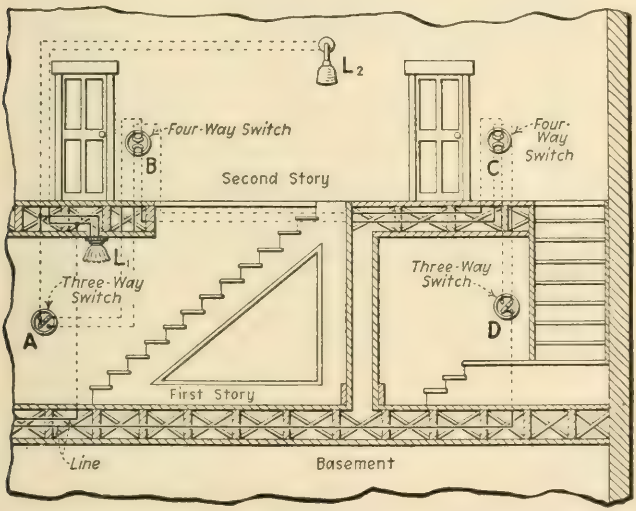


FIG. 255.—Illustrating an actual four-location control installation.

shows a similar installation in which three second-story hall lights, L_1, L_2, and L_3, and a first-story hall light, L_4, are controlled from three locations which are: First story, O, second-story rear hall, N, and second-story front hall, M.

227. Four-way Switches May Be Used Without Three-way Switches To Provide Control Of A Lighting Circuit From Three Or More Locations by following the directions diagrammed in Fig. 257. Obviously, this method is more expensive than one for which three-way switches are used (instead of the four-way switches) at A and B. However, it is some-

times necessary to thus use four-way switches when the three-way switches cannot be obtained.

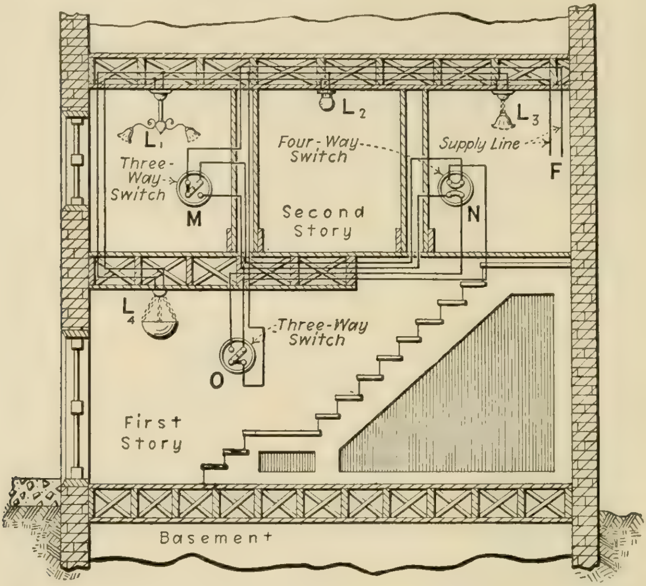


FIG. 256.—Four hall lights, L_1, L_2, L_3 and L_4, controlled from three locations.

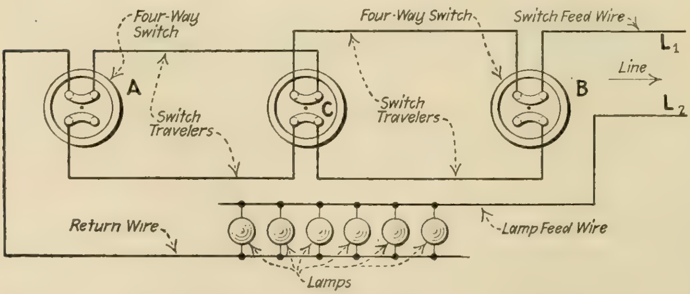


FIG. 257.—Three-location control using three four-way switches.

228. A Three-location Control May be Provided By Arranging Two Four-way Switches In Combination With A Single-pole, Double-throw Knife Switch wired as diagrammed in Fig. 258. This method of wiring is also more expensive than if the control were effected by the use of two standard three-way and one standard four-way switch. It illustrates an

improvisation which may be employed in special cases or in an emergency.

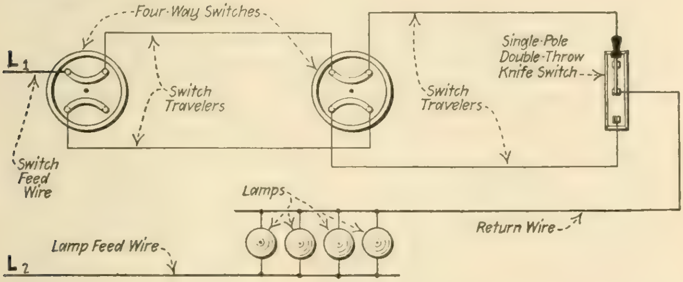


FIG. 258.—Three-location control; two four-way snap switches and one single-pole double-throw knife switch.

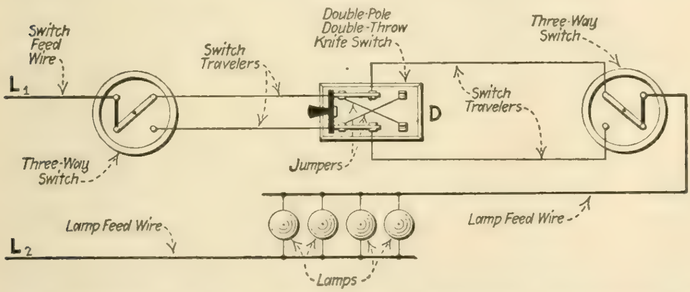


FIG. 259.—Two three-way snap switches and one double-pole double-throw knife switch for three-location control.

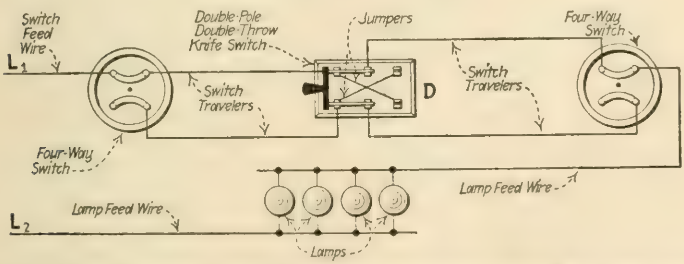


FIG. 260.—Three-location control using two four-way snap switches and one double-pole double-throw knife switch.

229. A Double-pole, Double-throw Knife Switch May Be Used To Provide A Third Control Location when installed in combination with either two three-way switches or two four-way switches, as portrayed in Figs. 259 and 260, respectively.

The reversing of the polarities of the switch travelers at the third control location, *D*, in Figs. 259 and 260 is accomplished by placing jumpers diagonally across the contact jaws on the double-throw switches, as shown in the illustrations.

230. A Four-location Control Utilizing A Single-pole Double-throw Knife Switch, A, A Double-pole, Double-throw

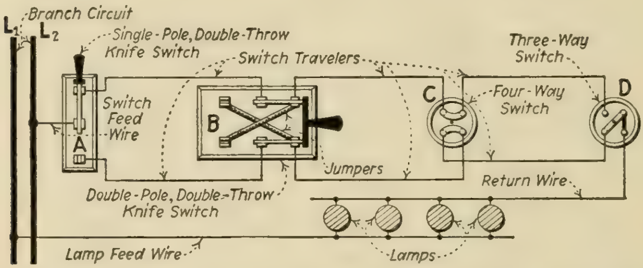


FIG. 261.—Combination of knife and snap switches for three- and four-way switch circuits.

Knife Switch, B, A Four-way Switch, C, and A Three-way Switch, D is illustrated in the diagram of Fig. 261. It will be noted that the polarity-reversing arrangement on the double-pole double-throw switch, *B*, is provided by jumpers bridging diagonally between the contact jaws as in Fig. 219.

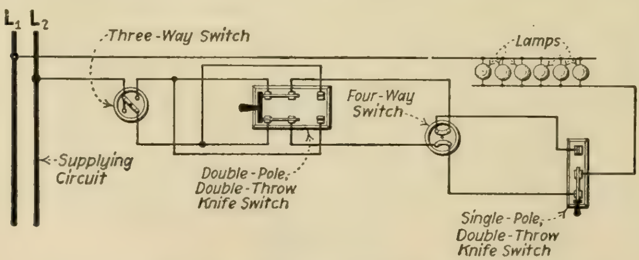


FIG. 262.—Another combination of switches for a four-location control.

This diagram demonstrates the latitude which is obtainable in the multi-location control of lighting circuits by using switches of different types. Another example of an installation, involving four different control locations, in which switches of a variety of types are used, is that presented in

Fig. 262. For multi-location control using knife switches only, see Div. 4.

231. A Restricted-control Switch Circuit For Hall Lights which provides an economical arrangement, when it is not desired at all times to have the hall-way brightly illuminated, is shown in Fig. 263. Three three-way switches, A, B_1 and B_2, are installed. Switch A is located on the second floor while switches B_1 and B_2 are located in gang on the first floor. The 10-watt and the 60-watt lamps at C are both mounted in the same fixture and tapped by the lamp feed wire at C.

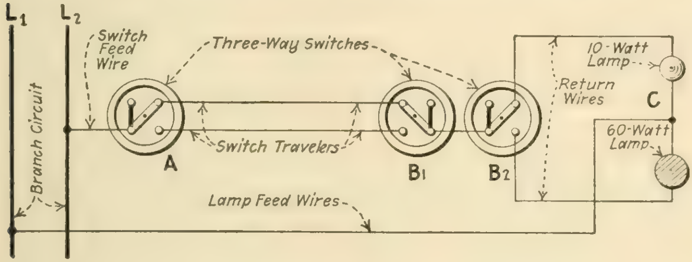


Fig. 263.—Restricted-control circuit for hallway lights.

Explanation.— If the circuit diagram is traced out it will be found that only one of these lamps can be lighted at any time and that the position of the contacts in switch B_2 determines which of the lamps will be cut in service. It will further be noted that neither of the lamps can be extinguished from switch B_2 without lighting the other, and vice versa. Either switch A or B_1 will, however, turn off whichever light happens to be burning and will, of course, turn it on again. But, if the 10-watt lamp is burning and it is desired to extinguish it and light the 60-watt lamp, this can be done only from switch B_2.

232. Another Restricted-control System For Hall-way Or Show-window Lights (Fig. 264) may be assembled by using a single-pole, S, a three-way, T, and a four-way, F, switch in combination. These connections afford about the same selection in lamp control as does an electrolier switch (Div. 7).

Explanation.—The single-pole switch, S (Fig. 264) controls the entire circuit. That is, if switch S is turned off, the lamp B and the lamp group A cannot be lighted at switches T and F. However, if switch S is in the "on" position, it is possible, as will be revealed by a consideration of the diagram, to control group A or lamp B from either the three-way

switch T or the four-way switch F. But at no time can group A and lamp B be lighted simultaneously. That is, when group A is lighted B is extinguished and when B is lighted group A is extinguished. It will be further noted from this diagram that both lamp B and group A cannot be extinguished simultaneously from either switch T or switch F.

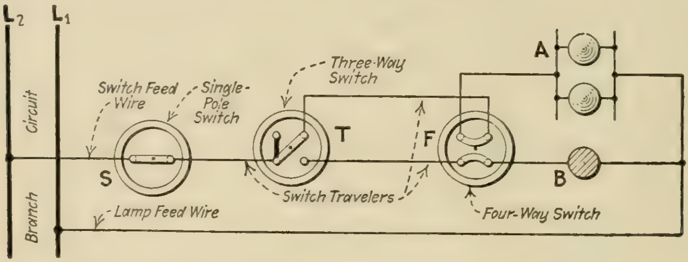


FIG. 264.—Another example of restricted control.

233. A Restricted Control Three-way Switch Circuit For Up-stairs And Down-stairs Hall Lamps is shown in Fig. 265. The arrangement, as illustrated, is for a three-lamp fixture, L_2 and L_3, located in the lower hall and a single lamp, L_1, located in the upper hall. The two three-way switches,

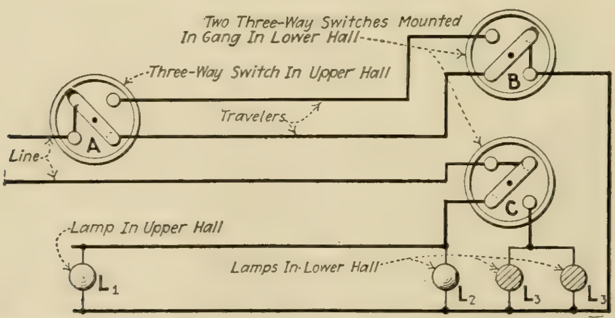


FIG. 265.—Two-location restricted control employing three three-way switches.

B and C, which are mounted in gang, are located near the entrance to the lower hall. Switch A is located in the upper hall. Lamp L_1 and L_2 comprise one lamp-group—although one is up-stairs and the other down-stairs. Lamps L_3 comprise the second lamp-group. Only one lamp-group—either L_1L_2, or L_3—can be lighted at one time. Either group may be extinguished or

lighted by either A or B, but the lamp-group which is so lighted or extinguished by A or B will be determined by the position of C.

EXPLANATION.—If a person, upon entering the lower hall wishes to light the lamps, he operates B. This will light one lamp-group—either L_1L_2, or L_3—and the lamp-group which is so lighted is determined by the position of C. If upon operating B, the lamp-group which lights is the one that is not wanted, the other lamp group may be lighted by operating C. If a person is in the upper hall and operates A, one of the lamp-groups will be lighted; if it is the wrong one, he must go down-stairs and operate C, whereupon the other lamp-group will be lighted. One of the lamp-groups—depending upon the position of C—may be lighted and extinguished by either A or B.

234. A Three-way Switch Circuit Providing Restricted Control From Either Of Two Locations is shown in Figs. 266

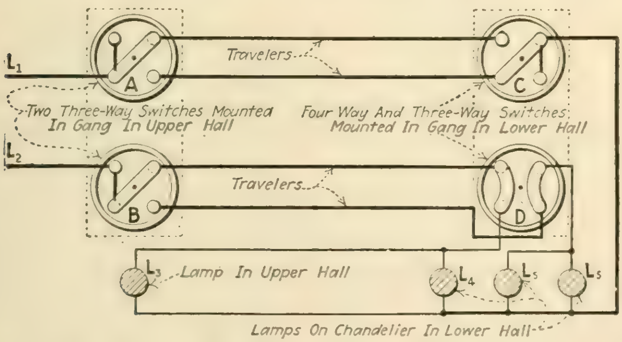


FIG. 266.—Restricted control of up-stairs and down-stairs hall-lamps from two locations. See Fig. 266A for installation lay out.

and 266A. The three-way switches, A and B, which are mounted in gang, and lamp L_3 may be located in the up-stairs hallway. Switches C and D, which are similarly mounted, and lamps L_4 and L_5 may be located in the lower hallway. Lamp L_3 and L_4 comprise one lamp-group, and lamps L_5 comprise another lamp-group. Only one lamp-group—L_3 and L_4, or L_5—can be lighted at any one time. The lamp-group which it is desired to light is selected by either switch B or D. The lamp-group so selected may be lighted or extinguished by either A or C.

EXPLANATION.—A person entering the lower hallway at night, when all lamps are out, operates switch C. This will light one of the lamp-

groups. The lamp-group—L_3L_4, or L_5—which is lighted thereby, will depend upon the positions of B and D. If the lamp-group which happens to light, upon operating C, is the one which is not wanted, switch D is then operated. The same results may be obtained from the upper hallway by operating switches A and B.

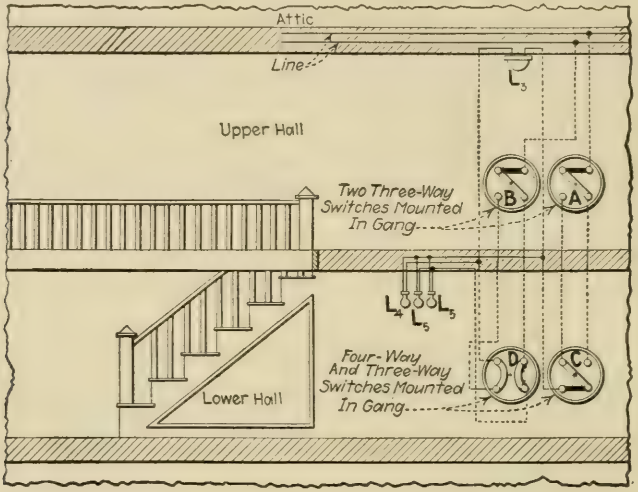


Fig. 266A.—Installation layout for circuit of Fig. 266.

235. A Combined Restricted And Selective Four-way Switch Circuit For Hallways Or Show Windows is shown in Fig. 267. With switch A open, restricted control (Sec. 15) is provided since only one lamp can be lighted at a time.

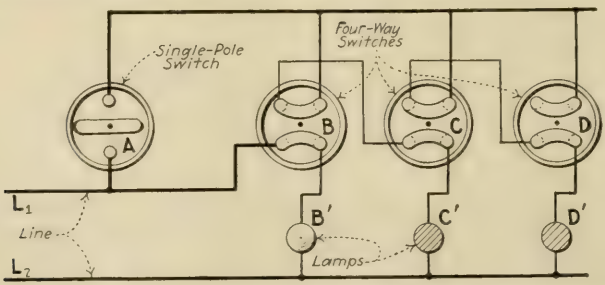


Fig. 267.—A combined restricted and selective circuit. (When A is open the control is restricted; when A is closed the control is selective.)

Explanation.—That is, if A is open, B' may be lighted by operating B. Then before the operation of C will light C', B must be operated

to extinguish B'. And before D can be operated to light D', both B and C must be placed so that both B' and C' are extinguished. With switch A closed, all three of the lamps, B', C', and D', will be lighted regardless of the positions of B, C, or D.

NOTE.—A THREE-WAY SWITCH CIRCUIT PROVIDING RESTRICTED CONTROL WHICH IS INTENDED TO MINIMIZE CURRENT CONSUMPTION is shown in Fig. 268. Such an arrangement is well adapted for *guest-rooms.* Only one lamp-group can be lighted at any one time.

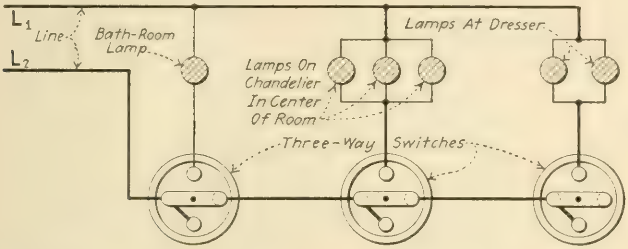


FIG. 268.—Restricted control of lamps provided by three-way switches. (Only one lamp or group of lamps can be lighted at a time.)

236. An Example Of The Simultaneous Control Of Three Hall Lamps from any of three locations, A, B, and C, is shown in Fig. 269. This arrangement of switch control is, in general, similar to that diagrammed in Fig. 256 and is merely a modification, to satisfy a given set of conditions, of a typical three-way-four-way switch circuit.

237. A Stairway Lighting Circuit Wherein Restricted Selective Control Is Effected by the use of three-way, single-pole and double-pole switches is illustrated in Fig. 270. The object of this installation is to provide a system whereby one can illuminate the stair landing at which he happens to be as well as the one either above or below him as he goes up or comes down the stairs. The switch at each landing is operated in passing.

EXPLANATION.—Assume that the two single-pole switches (Fig. 270) on the fifth floor are in the "on" position and that the three-way switches on the fourth, third and second floors are in the positions indicated, and that the double-pole switch on the first floor is in the "off" position. Now, it is obvious that if a person on entering the building, will throw the double-pole switch at the first-floor stair landing he will light the hall lamp on the first floor as well as the hall lamp on the second floor. He mounts the stair and when he reaches the second-floor landing operates

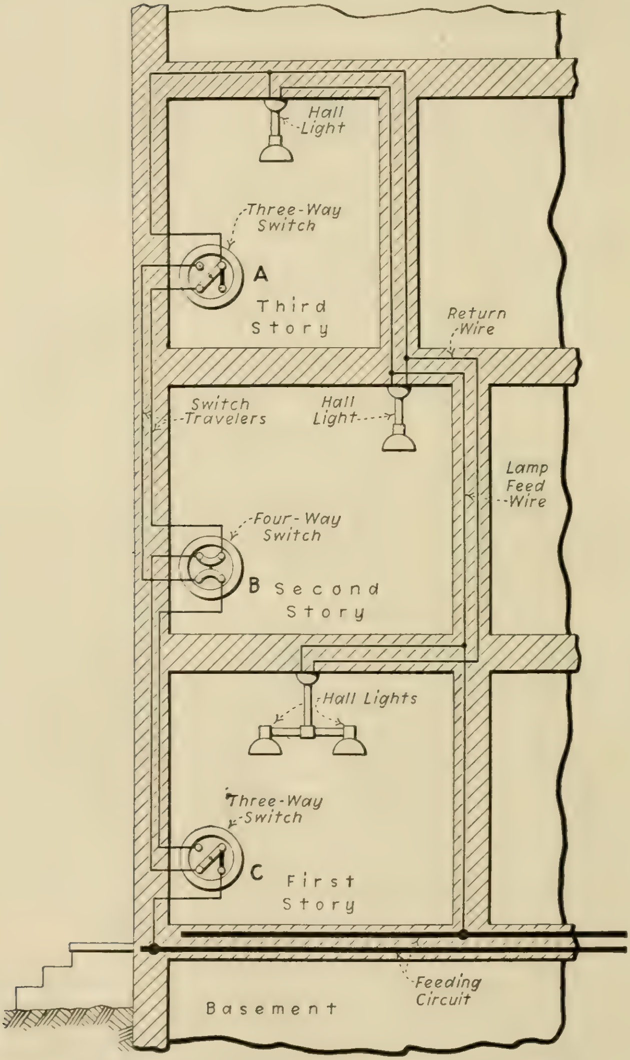


FIG. 269.—Simultaneous control of lamps from three locations.

the three-way switch there so that the contact is reversed from that shown by the illustration. This, as will be evident from a study of the diagram, lights the hall lamp on the third floor and at the same time extinguishes the first-floor lamp. The second-floor hall lamp remains lighted. Now, he mounts to the third floor and reverses the contact of the three-way switch there which extinguishes the lamp on the second floor and at the same time lights the one on the fourth floor. Upon reaching the fourth floor he reverses the contact of the three-way switch at the stair landing there which extinguishes the third-floor lamp, at the same time lighting the fifth-floor lamp. Both the fourth-floor lamp and the fifth-floor lamp can be extinguished by the single-pole switches shown at the fifth-floor landings.

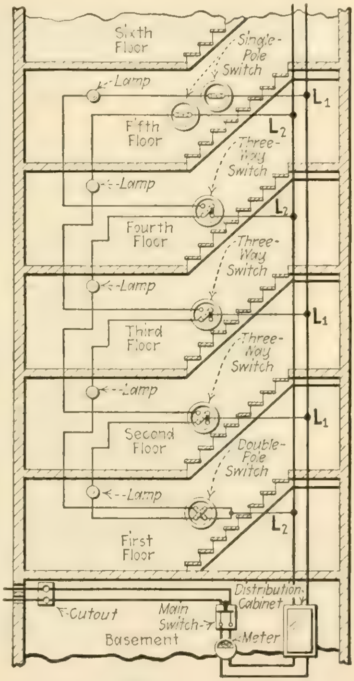


FIG. 270.—For control of stairway lights as a person goes up or down.

Coming down the stairway (all of the three-way switch connections having just been reversed from those shown in Fig. 1, if it is desired to illuminate the fifth-floor hall lamp and the fourth-floor hall lamp the two single-pole switches at the fifth floor are both thrown to the "on" position. Now, having descended to the fourth floor hall he operates the three-way switch there which extinguishes the fifth-floor hall lamp and lights the third-floor hall lamp; the fourth-floor lamp remaining lighted. Descending to the third floor the three-way switch at the stair landing there is operated, which disconnects the fourth-floor hall lamp and lights the second-floor hall lamp, the third-floor lamp remaining lighted. Now after descending to the second floor, the three-way switch there is operated which disconnects the hall lamp on the third floor and connects the one on the first floor, the second-floor hall lamp meanwhile remaining connected. Then having reached the first-floor stair landing the double-pole switch there is thrown to the "off" position and this operation extinguishes both the first and second-floor hall lamps.

From the foregoing it will be evident that the switches on the second, third, fourth, and fifth floors are now in the position in which they originally were and that the lamps on these floors may be successively lighted as first described. *Discretion must be used in applying this circuit*

because for successful operation the switches must be manipulated exactly in the sequence outlined. If some person other than the one who is mounting or descending the stairs steps out on one of the floors and turns a switch, the control will be disorganized. When a misconnection is thus effected considerable difficulty may be encountered in locating the trouble.

238. Another Three-way Switch Circuit For The Control Of Hallway Or Stairway Circuits is diagrammed in Fig. 271. An installation, when arranged according to this scheme permits any lamp to be lighted or extinguished, independently of

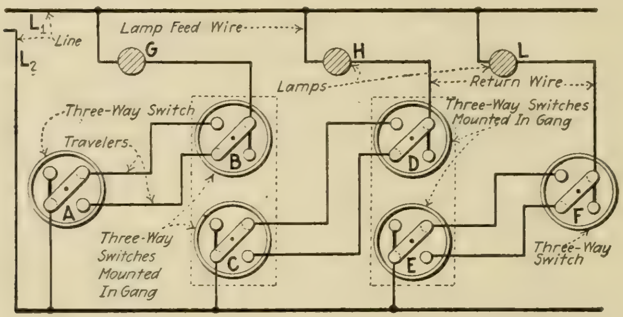


Fig. 271.—Three-way switch-circuit for hallway or stairway lamps.

any other lamp, from each of two locations. Such an arrangement is particularly adapted for stairway lighting, and for lighting a series of hallways which are at right-angles with respect to each other. Whether for hallway or stairway lighting, the switches *A* and *F* should be located, respectively, at the entrance and the exit of the passageway. The intermediate gang switches, *BC* and *DE*, should be installed at or near a turn. The lamps, should be located one between each switch location about midway of a straight run of the hall or stair.

Explanation.—A person, upon entering the passageway operates switch *A* to light lamp *G*. This lamp, which is located between *A* and *BC*, then lights the way to *BC*. At *BC*, lamp *G* may be extinguished by switch *B* and lamp *H* lighted by *C*, whereupon the person may proceed along a lighted pathway between *BC* and *DE*. If at *DE*, say, the person wishes to enter a room and leave the passageway unlighted, *H* may be extinguished by *D*. If there are doors along the side of any of the hallways at which a control for the lamp in that hallway

is desired, such control locations may be provided by connecting four-way switches into the travelers (see Fig. 251) and installing the switch at the desired place. Note that a person may enter the passageway, proceed in either direction, and have a lamp always lighted in front of him, and extinguish the lamps behind him. The principal objection to this arrangement is the large amount of wire which is required (see Sec. 254 and Fig. 292).

239. A Practical Installation Of Three-way Switches For Storerooms And Warehouses, is that in the installation shown

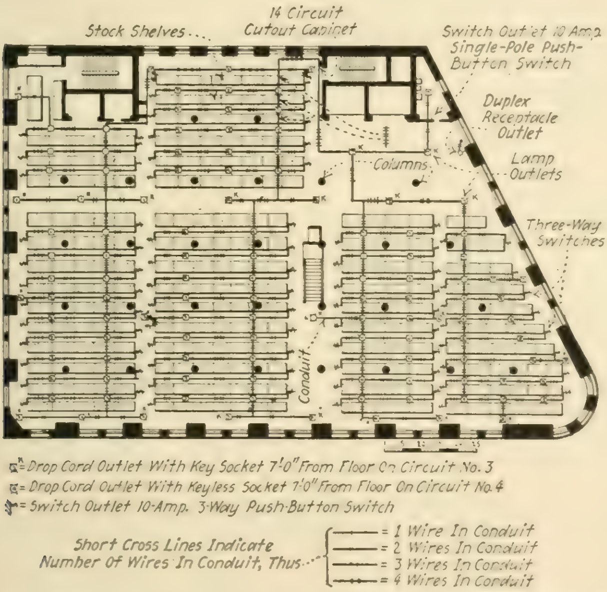


Fig. 272.—Wiring diagram showing conduit installation of three-way switches in second-floor stockroom of Cluett-Peabody Company, Chicago. *L. H. Lamont & Co., Contractors.*

in Fig. 272. The problem was one of providing adequate lighting for the numerous bins and stock shelves of this room, in which is kept a large stock of men's wear, and at the same time keeping the electric-energy consumption as low as possible. It was very desirable not to have the lighting arrangement interfere with the efficiency of the workmen. The nature of this stock is such that the orders invariably consist of a wide variety of different articles in small quan-

tities. The individual orders are usually gathered by one man from the different shelves and taken to the wrapping table (not shown) which is situated in the upper right corner of the room. Three-way switches were used as indicated to effect the desired control.

Explanation.—If key sockets alone were used a man who is "gathering" an order, in order to turn on the light, would have to drop whatever stock he was carrying at the time, turn on the light, pick whatever stock was needed, turn off the light and grope his way out in the dark, or the light would have to be kept burning. As it often happens that the stock from certain sections is needed but once or twice during the day, this latter method would not be desirable as it would entail an unnecessary waste of energy. As the workmen have adopted a progressive system of gathering the stock, by which they start from one point and fill the various items as they go along, single-pole switches could not be used to advantage as they would necessitate going back to the point where the switch was located.

This problem was practically solved by the installation of 88 three-way switches, one at each end of each tier of stock shelves. As is evident from the diagram the gatherer can with this arrangement, start from any point, turn on the lights in any tier by means of the three-way switch located near the entrance, pick the stock required from that tier and, on leaving the tier at the other end, turn the lights off. Although slightly more expensive than a similar installation using single-pole switches or key sockets, the saving in energy-consumption is expected, in a short time, to offset this additional cost. (Electrical Review, Feb. 15, 1919.)

240. A Garage Three-way Switch Circuit Wiring Diagram is illustrated in Fig. 273. In this illustration the three-way switch, *A*, is located within the owner's house while three-way switch *B* is located within the garage. This arrangement renders it possible to light or extinguish the garage lamp, *L*, from both switches, *A* and *B*. If it is desired to install an electric heater on this same circuit so that it will operate on its own switch, independently of three-way switches *A* and *B*, the wiring for such an extension may be installed as diagrammed in Fig. 273-*II*, which will, as shown, necessitate an extra run of wire from three-way switch *A* to heater switch *S*.

Note.—If The Garage Three-way-circuit System Is Laid Out In Accordance With The Carter System (Sec. 249) the diagram will

then be as shown at Fig. 273-*III*. With the Carter system, an extension for a heater circuit operating independently of three-way switches *A* and *B* may be installed as shown in *IV*. A saving in wire is thus effected, as is evident from a comparison of the diagrams of *II* and *IV*.

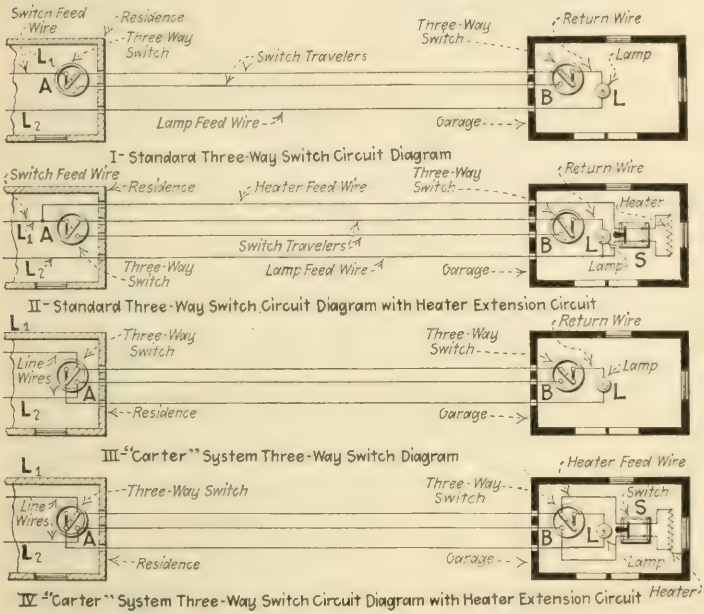


FIG. 273.—Standard and Carter system three-way switch circuits for the control of garage lights. (This illustrates the economy in wire which, under certain conditions results from the application of the Carter System.)

241. The Wiring Diagram For A Remote-control Vacuum Cleaner Motor Installation, ½ to 2 hp., which is served by an alternating-current single-phase line, is illustrated in Fig. 274. The connections on the basement panel board are not shown in this diagram. But the switch feed wire, after passing through the main fuse and knife switch at the left of the board, enters the magnetic switch, passes through it, thence through the three-way, four-way and three-way switch combination and thence to the motor. The other line wire serves the motor direct. The instállation of a magnetic switch is not justified for the smaller motors. For these, the switch feed wire, after passing through the main fuse and switch, enters

the three-way, four-way and three-way switch combination and thence is carried directly to the motor, as is obvious from a study of this diagram. The remote or independent control of the vacuum-cleaner motor is accomplished at the first, second, third, and fourth floors, as shown, in a manner similar to that described in Sec. 225 and diagrammed in Fig. 253.

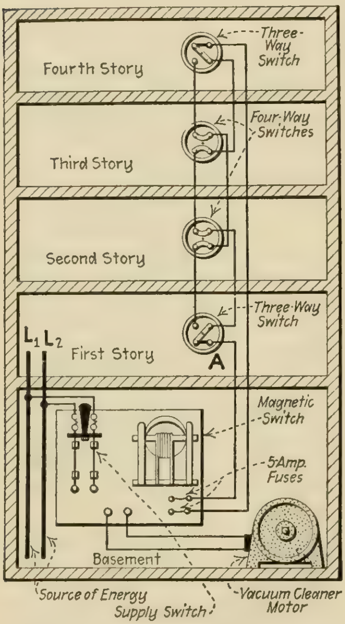


FIG. 274.—Remote control of vacuum cleaner motor using three- and four-way switches.

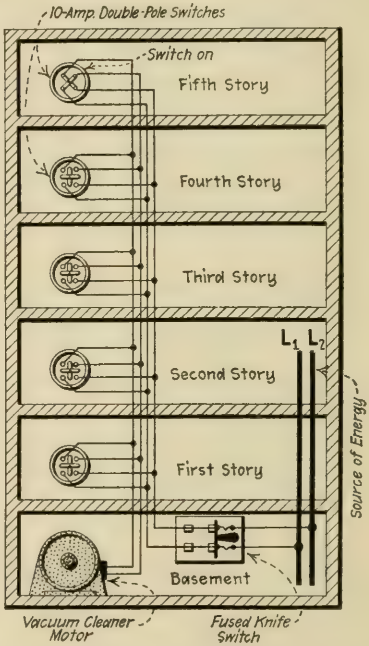


FIG. 275.—Control of vacuum-cleaner motor with double-pole switches.

NOTE.—IN MAKING AN INSTALLATION WHICH IS BASED ON THE USE OF AN ARCO WAND CLEANER, one of the three-way switches (*A*, Fig. 274) should be located at a point not to exceed 4 ft. distant from the cleaner relief valve so that both may be readily reached simultaneously. The reason for this is that, when cleaning the gauze sieve in the relief valve of an Arco cleaner, the operator must be able to throw on the switch controlling the motor and at the same time manipulate the relief valve. If the switch *A* were located out of reach of the relief valve, then it would be necessary for a person cleaning the gauze sieve to have an assistant turn the switch *A* on and off.

242. A Vacuum-cleaner Wiring Diagram for ½ And ¾-hp. Motors which provides independent control at five stations, is illustrated in Fig. 275. A study of this circuit will render obvious the sequence of operation. The double-pole switches, which are used on each of the floors, work independently of each other. That is, if the first-story switch is turned to the "on" position, the operation of the motor can be stopped only by turning this same switch to the "off" position. It cannot be controlled from any of the other switches at either the second, third, fourth, or fifth stories (see Sec. 241).

243. The Determination Of Three-way-switch-circuit Conductors, that is, the identification of the proper wires at the switch outlets, before connection to the switches, is sometimes

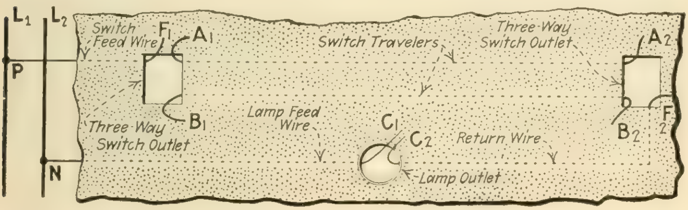


FIG. 276.—Conductors of a three-way switch circuit as they appear at the outlets before connection to the switches.

confusing to the wireman. There are (Fig. 276) always three wires at each of the two three-way switch outlets. One pair of wires A_1A_2 and B_1B_2 at each outlet extends, in the standard connections (Sec. 249) between switches, as shown in preceding illustrations and in Fig. 276; these wires are designated as "*switch travelers*" (Sec. 14). The third wire, $P\,F_1$, from one of the switch outlets is connected to one (for example, the positive) side of the branch feeding the three-way circuit and is designated the *switch feed wire*. The third wire, F_2C_2, at the other switch outlet returns to the lamps; this wire is termed the *return wire*. The wire C_1N which connects the lamps to the other side of the circuit is called the *lampfeed wire*. The switchfeed and the return wire at each three-way switch outlet should be marked for identification, prior to "testing out and connecting up" for service. This may be done by twisting them together, knotting them, nicking the

insulation or baring ("skinning") their ends. If the ends of the wires are thus bared for identification this will save time when the wireman tests out. It is unnecessary to mark either of the traveler wires for identification against one another as it is immaterial in what position, relative to one another they are connected.

Note.—A Method of Testing A Three-way Switch Circuit Which Has Been Installed as in Fig. 276 wherein the switchfeed, PF_1, and the return wire, F_2C_2, at each switch outlet have been previously marked for identification, follows. This "testing out" is to insure that the wires have been properly identified and connected. The circuit may be tested either with a bell-and-battery set or with a magneto,

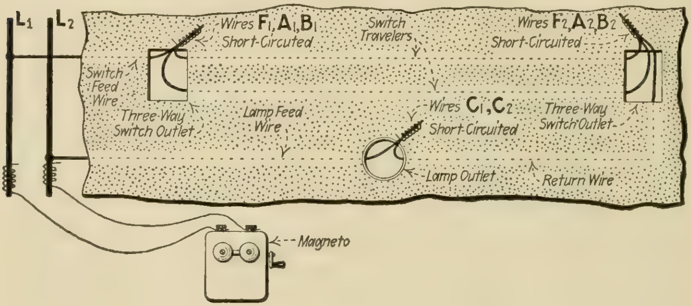


Fig. 277.—Testing complete three-way circuit for continuity.

as in Fig. 277. While in this illustration the magneto is, for convenience, shown connected to the brânch circuit wires, it is usual to "ring out" the circuit direct from the distribution center where the wires are tapped to the branch blocks. The object in "ringing out" a circuit, the wires of which have been properly identified as previously described, is merely to ascertain whether all of the wire runs are continuous and whether or not the connections to the branch circuit have been properly made. To do this it is only necessary to short-circuit wire ends (Fig. 277) $F_1A_1B_1$, $F_2A_2B_2$, and C_1C_2. Then ring out the circuit. If the magneto rings when operated, the circuit is in all probability continuous and properly connected. However, if it is impossible to "get a ring" from the magneto there are two possible causes of the difficulty: (1) *The connections are "off circuit,"* that is, both of the feed wires to the circuit are connected to the same branch wire. (2) *There is a break or open* in one or in several of the component conductors of the three-way circuit.

244. If It Is Necessary To Ascertain Which Are The Switch Feed, Which The Return Wires And Which The Switch Travelers in the event that the switch feed and return wires

have not been properly marked for identification when installed, this may be done (Fig. 278) by ringing out and isolating traveler wires A_1A_2 and B_1B_2. The third remaining wire at each of the outlets will, of course, be the switch feed and return wire respectively. Sometimes the switch outlets are too far apart to permit of the ringing out the traveler wires A_1A_2 and B_1B_2, in this manner. In such cases (Fig. 276), short circuit, that is connect together, wires $F_1A_1B_1$ and test successively, with the magneto, across any two of the three wires, $F_2A_2B_2$ at the distant three-way switch outlet until

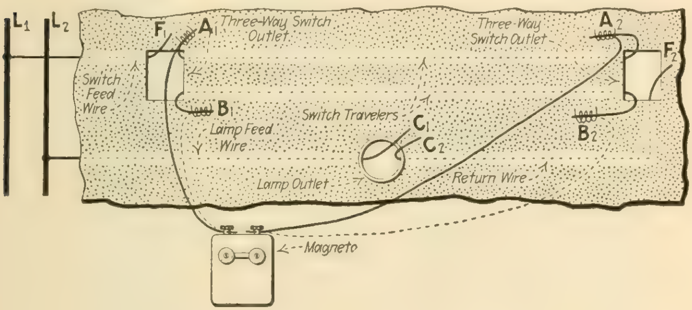


FIG. 278.—Testing to identify the travelers.

the magneto rings. The two wires on which the magneto rings will be the travelers. Now, connect together these two traveler-wire ends and test successively, with the magneto, across any two of the three wires at the first switch outlet, F_1A_1 and B_1 until the magneto rings. This will identify the travelers at the first outlet.

NOTE.—WHILE MAKING THIS TEST, wires C_1 and C_2 at the lamp outlet should not be connected together. When the travelers have been identified at one outlet as at A, Fig. 279, they can be connected together there as shown and tested out at the other outlet with a bell-and-battery set. This method of isolating the traveler wires is essentially the same as that just described but shows the test as being conducted with a bell-and-battery outfit.

245. To Ring Out The Feed Wires connect wires C_1 and C_2 at the lamp outlet, Fig. 276, and (after short-circuiting the branch wires at the distribution cabinet) connect the magneto

to wires F_1 and F_2. If the connections at the branch are correct the magneto will ring. If the magneto rings when the branch wires are not connected together it is probable that the

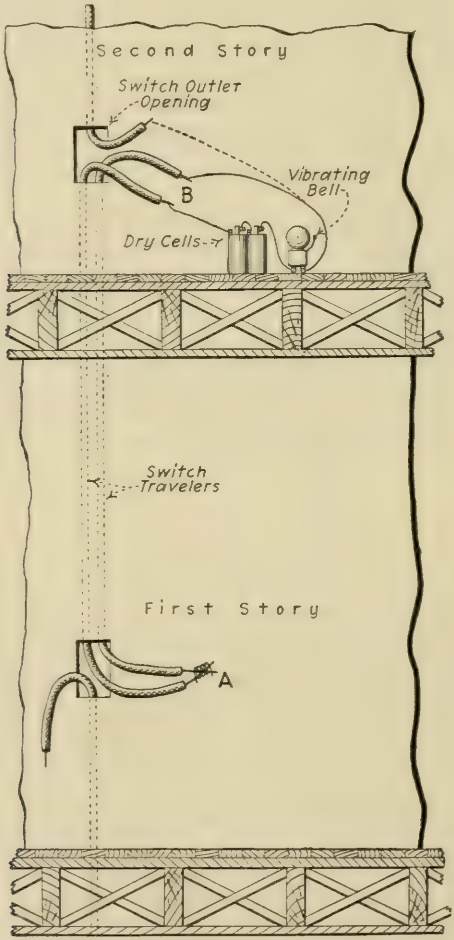


FIG. 279.—Method of testing out a three-way switch circuit with an electric bell.

switch-feed wire and lamp-feed wire connect to the same side of the branch circuit. The remedy for such trouble is obvious.

246. Testing Out A Three-way Switch Circuit Installed In A Conduit System is illustrated in Fig. 280. This test may be

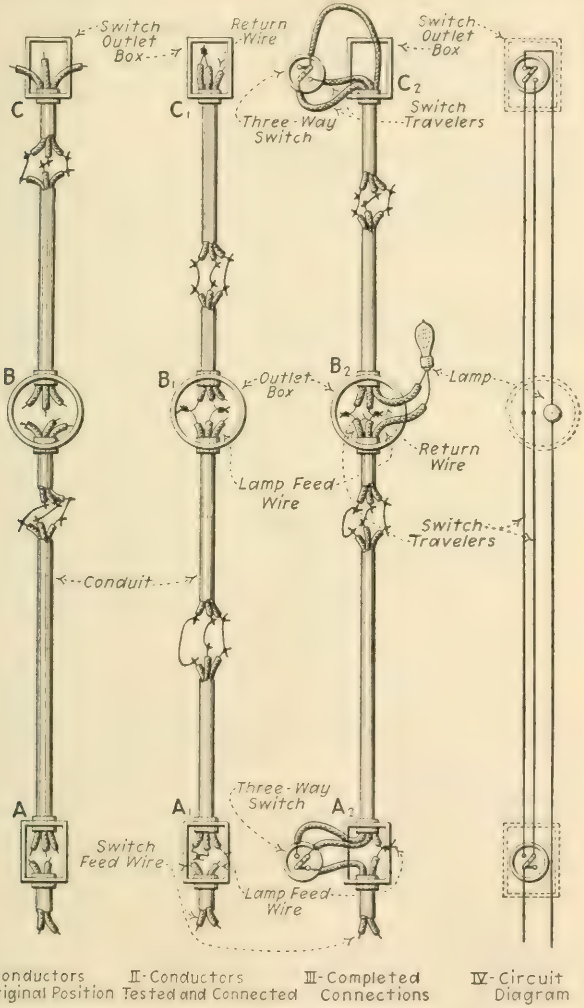


FIG. 280.—Identifying conductors in a three-way switch circuit in conduit.

conducted with either a magneto or with the bell-and-battery outfit previously described (Sec. 244). The diagram of Fig. 280 may, at first, seem much more complicated than those of

Figs. 276, 277, 278 and 279. But this is due to the fact that in the conduit system shown all of the wires in the circuit are carried within the same conduit run. The manner of isolating the feed and the return wires is exactly the same as that explained in conjunction with Figs. 276 to 279, inclusive. In a conduit installation like that of Fig. 280, it is an excellent plan

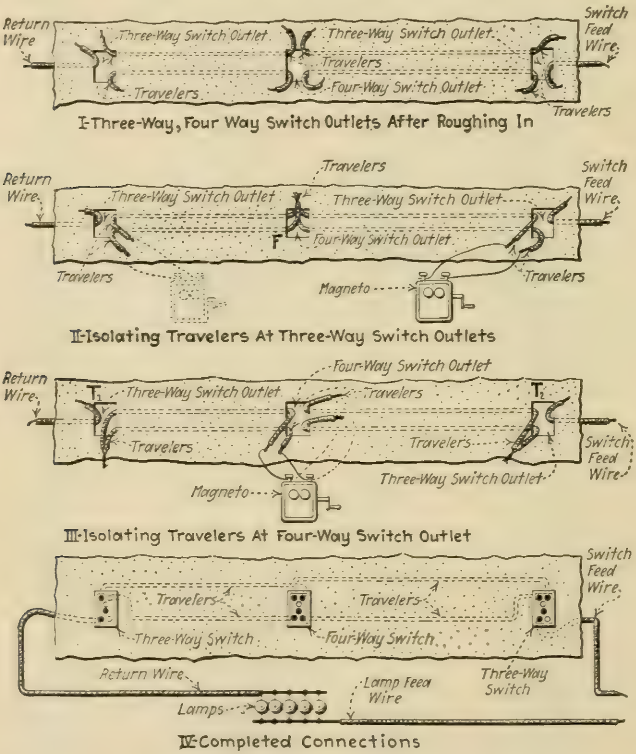


FIG. 281.—Identifying the conductors of a three-location control circuit.

to use duplex wire for the switch travelers and a single-conductor wire for the switch feed and the return wires. The use of conductors of these types will eliminate the necessity of testing out the circuit, after its installation, to determine the identity of the various wires.

247. To Test Out A Three-way, Four-way Switch Circuit (Fig. 281) first identify the switch feed wire to one three-way

switch and the return wire from the other three-way switch. This may best be done, as shown at *II*, by twisting together the bared ends of the four wires (at the four-way switch outlet, *F*) which form the two sets of travelers between the four-way switch and the two three-way switches. Then ring out the wires at each of the three-way switch outlets, as shown at *II*,

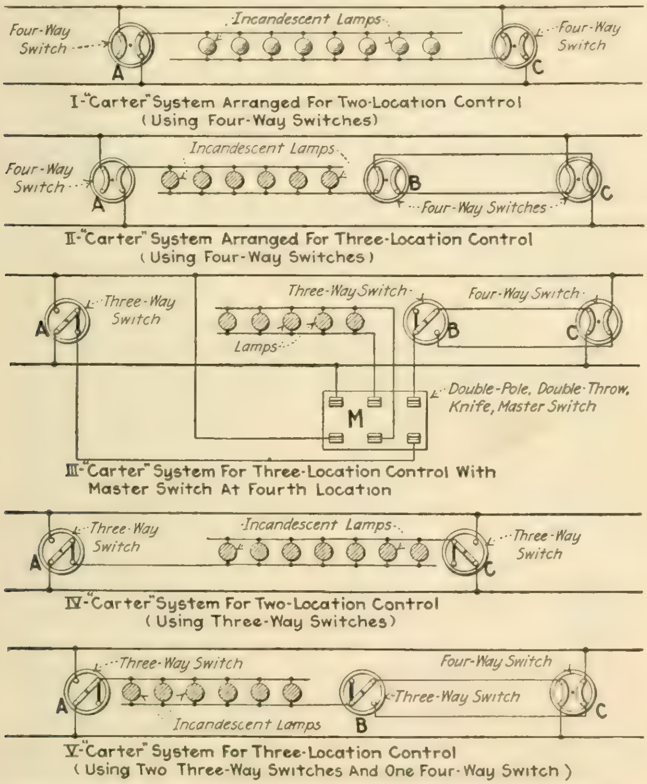


FIG. 282.—Showing wiring diagrams of the so-called "Carter" system.

until the two traveler wires are found the other ends of which have been short-circuited by being twisted together at the four-way switch outlet *F*. The remaining wire, at each of the three-way switch outlets, is the switch-feed wire in one case and the return wire in the other. These switch-feed and return wires should each be marked by knotting, baring their ends, notching the insulation, or otherwise.

248. The Other Two Wires At Each Of The Three-way Switch Outlets, T_1 and T_2 (in Fig. 281, *III*) which form the travelers to the four-way switch should now have their bared ends twisted together, as shown. The bared ends of the four wires in the four-way switch outlet are untwisted and each is rung out with the other until it is found which of the wires pair with one another. The two sets of travelers having thus been identified and paired, they are now connected to the four-way switch binding posts, as shown in the illustration of *IV*. The two travelers and the return wire are connected in one three-way switch as shown at the left of *IV*, while the switch feed wire and the two travelers are connected to the other three-way switch as shown to the right of *IV*.

249. The So-called "Carter" System Of Multi-location Lighting-circuit Control (Fig. 282) is one wherein two or more

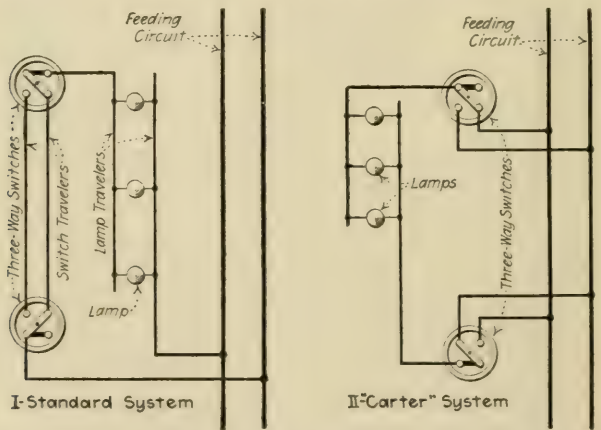


FIG. 283.—Diagrammatic definitions of the "Standard" and the "Carter" systems of wiring three-way switch circuits.

three- or four-way switches (*A* and *C*, Fig. 282) is connected to both sides of the line. Various Carter-system circuits and connections, and also the advantages and disadvantages of this system are discussed in the following sections.

NOTE.—THE USUAL METHOD OF WIRING THREE- AND FOUR-WAY SWITCH CIRCUITS, which has been described in preceding sections is herein called the *standard* system (see Fig. 283) to distinguish it from the *Carter system.*

250. The Carter System Is Often Employed To Effect A Wire-saving (Fig. 284). The location of the lamps and switches shown in Fig. 284 is an exact replica of that in Fig. 255. However, in Fig. 284, the Carter system of wiring is

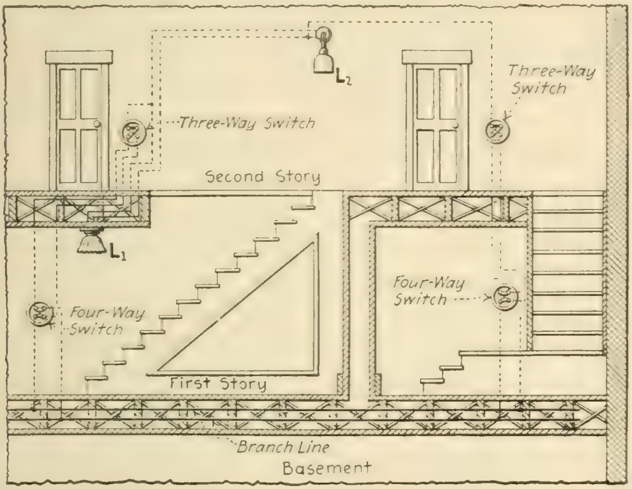


FIG. 284.—Illustrating an actual four-location control installation using Carter system.

used, whereas in Fig. 255, the wiring is the standard (Sec. 249) method. By scaling the length of wire which is used in each installation (Figs. 255 and 284), it will be found that approximately twice as much wire is required for the installation of

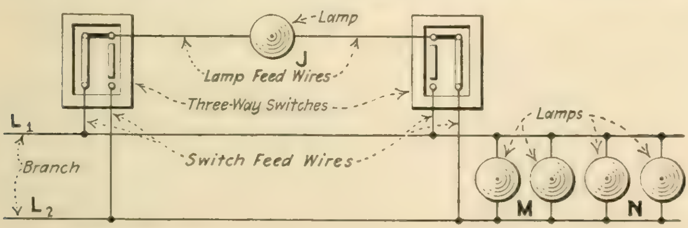


FIG. 285.—Simple "Carter" system two-location control circuit.

Fig. 255 as for that of Fig. 284. Since with the Carter system, it is possible to connect additional lamps (*M* and *N*, Fig. 285) in the branch circuit beyond the furthest three- or four-way switch, an additional wire-saving, which is not shown by Fig.

284, may frequently be effected by utilizing this same branch circuit for lamps which are located in other rooms. These lamps (*M* and *N*, Fig. 285) are entirely independent of those, *J*, controlled by the three-way switches, that is, they can not be lighted or extinguished by the three-way switches.

251. The Carter System Of Wiring Is, In Some Cities, Prohibited By Ordinance. This is probably because of the fact that the first three- and four-way switches which were marketed did not possess a positive and quick "snap action," but were slow and "draggy" in breaking the circuit. Both sides of the line are (Sec. 249), in the Carter system, connected to each of the "end-switches." Hence, this slow-break mechanism of the pioneer three- and four-way switches frequently, during operation, short-circuited the line. However, a properly-constructed three- or four-way snap switch, when both sides of the line are connected to it, will, probably, present no greater *fire hazard* than will a double-pole snap switch when both sides of the line are connected to *it*.

Note.—The Carter System Of Connection For Three- And Four-way Switches Is Not Contrary To 1920-Code Requirements in spite of the fact that it was formerly, in most quarters, held to constitute a Code violation. It is obvious that if a single-pole switch is connected to both sides of the line, a short-circuit will result upon closing the switch. This fact, together with an erroneous interpretation of Code Rule 24*c*, Par. 3, (see Sec. 144) to the effect that three-way switches are, *in every respect*, to be considered as single-pole switches, has led many inspectors to prohibit the Carter connections. However, three-way switches are properly considered as single-pole switches (Rule 24*c*, Par. 3), *only* insofar as the requirements of Rule 24*c*, Par. 1 (see Secs. 141 and 142) are concerned.

Note.—It Is Very Likely That The 1923-Code Will Contain The Following Three-way-switch Rule (see note under Sec. 118): "Three-way switches are considered as single-pole switches and shall be so wired that only one (1) pole of the circuit will be carried to either switch." If this rule is incorporated in the 1923-Code, the "Carter" system of connecting three- and four-way switches as described herein will be a violation of Code requirements.

252. Some Of The Switch Combinations Which May Be Used In The Carter System are shown in Figs. 286, 287, 288 and 289. Figure 286 shows three-way snap switches used for two-location control wired in accordance with the "Carter"

system. In Figs. 287 and 288 are shown respectively three-way and four-way snap switch combinations and three-way

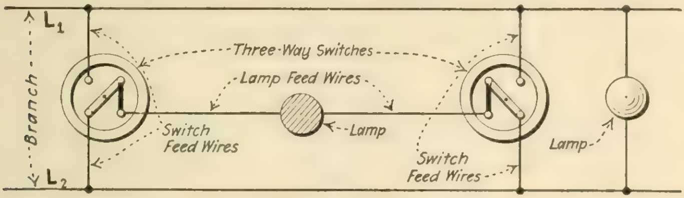


Fig. 286.—Three-way surface snap switches used for Carter-system two-location control.

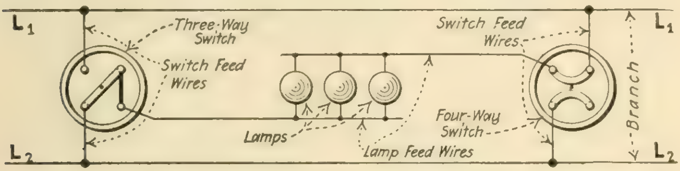


Fig. 287.—A three-way switch and a four-way switch arranged for a Carter system two-location control.

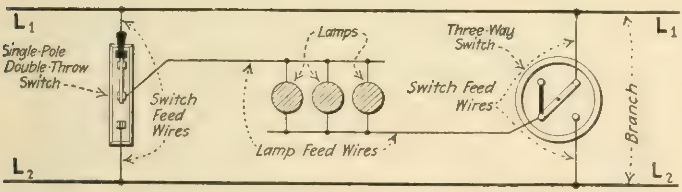


Fig. 288.—Carter system. Two-location control using a single-pole double-throw knife switch and a three-way surface snap switch.

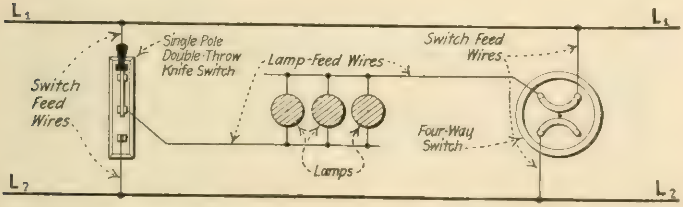


Fig. 289.—Carter system two-location control using a single-pole double-throw knife switch and a four-way surface snap switch.

single-pole double-throw knife switch combinations. Both are for the two-location control of a lighting circuit. Figure 289 shows a single-pole double-throw knife switch and a four-

way surface snap switch installation providing a two-location control of a lighting circuit.

253. The Carter System Of Two-location Control Of Lamps Which Are Fed From Different Branches (Fig. 290)

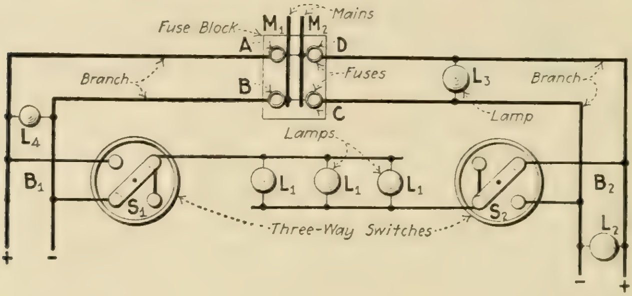


FIG. 290.—Two-location control by Carter system connected to two branches.

will frequently effect a considerable saving in wire over the same system connected to the same branch. Any trouble on the Carter circuit of Fig. 290 may be difficult for an inexperienced person to locate, otherwise there should be no particular

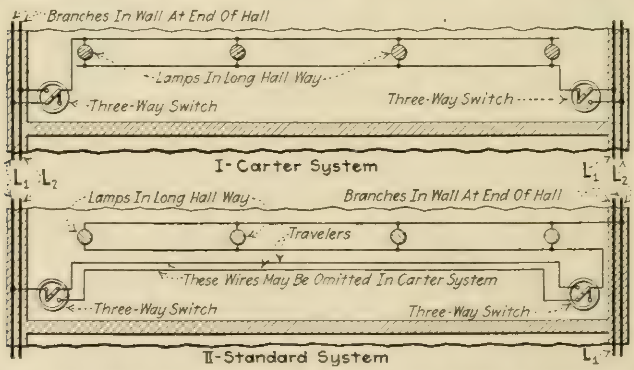


FIG. 291.—Showing a wire-saving effected by the Carter system of connection over Standard system of connection. This diagram shows a two-location control of lamps in a long hall-way which has branch circuits in its end-walls.

difficulty with such an arrangement. In Fig. 290, if a fuse "blows" some of the lamps may burn at one-half voltage. Which lamps will burn at the low-voltage will depend upon which fuse ruptures, and also on the position of the switches,

S_1 and S_2. If, with the switches S_1 and S_2 in the positions shown, fuse C becomes inoperative while lamps L_3 and L_2 are, by their individual switches, turned on, the result will be that the lamps in lamp-group L_1, and also lamps L_2 and L_3 will burn at one-half normal voltage if S_2 is operated. Note that fuses A and C may both be removed and lamp-group L_1 can still be lighted. The method shown in Fig. 291 is particularly adaptable for night-watchman's use when it is desirable to enter the hallway at one end and leave from the other.

254. Hall-way Or Stairway Lighting By The Carter System may be obtained as illustrated in Fig. 292. The control provided by, and the operation of this arrangement, is identical

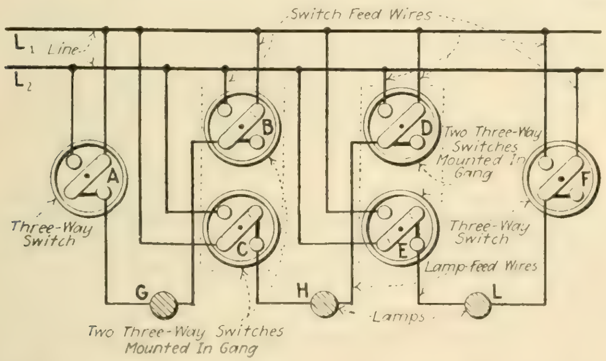


FIG. 292.—Carter connections for three-way switch-circuit for hallway or stairway lamps. (Every lamp adjacent to any switch-location may be either lighted or extinguished, by operating the switches at that location.)

with that described in Sec. 238 and Fig. 271. However, the quantity of wire required for the installation of Fig. 292 is only about 70 per cent. of that required for Fig. 271.

255. Another Three-and-four-way, Carter Connected Switch Circuit For Hall-way Or Stairway Lighting is shown in Fig. 293. The switches should be located at the turns in the passageway and the lamps midway between the switches. The operation of this installation is not as flexible as that which is outlined in Sec. 254. If, as explained below, all lights are to be left "off," all switches must be operated successively in sequence. This circuit is, in general, an undesirable one for the same reason given in connection with Sec. 237, and Fig.

270—if it becomes disarranged by the operation of the switches in incorrect sequence, it is somewhat difficult to so turn the switches that the circuit will operate properly.

EXPLANATION.—With the switch-blades in the position as shown in Fig. 293 all lamps are "off." If a person enters the passageway and operates switch A, lamp A' is lighted. By passing through the passageway—which is lighted by A'—to switch B, and operating switch B, A' is extinguished and B' is lighted. Thence, proceeding to, and operating C, B' is extinguished and C' is lighted. Thus, by going throughout the entire hallway—from A to E, inclusive—and operating each switch in passing, all lamps will be left extinguished.

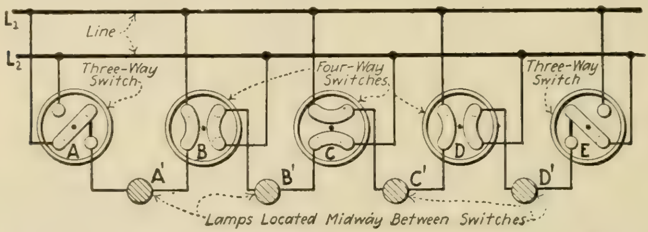


FIG. 293.—Carter-connected hallway or stairway lighting circuit. (Each switch must be operated in passing. With the switches in the position shown, lamp A' will be lighted by operating switch A. Then, upon operating switch B, lamp B is lighted and A' is extinguished. Then, operating switch C, B' is extinguished and C' lighted and so on.)

All lamps may be lighted and left lighted by going through the passageway and operating only alternate switches—that is, if going in the direction from A to E, by operating switches A, C, and E. All lamps may then be extinguished and left extinguished by: (1) *Passing from A to E and operating B and D.* (2) *Passing from E to A and operating E, C, and A.*

If a person enters the hallway at, say, C, (when the switchblades are in the position shown), and operates C, lamps B' and C' will be simultaneously lighted. Then if he proceeds in either direction and operates each switch in passing, one lamp—B', if he goes toward A, and C' if toward E—will remain lighted. If the system is thus disarranged, it may be again placed in order by going through the hall in the opposite direction from that traversed by the person so disarranging it, and operating only those switches which were not operated by him.

256. The Conductors, As They Appear At The Outlets Before Connecting To Switches And Lamp, For Two-location Control Of Carter-connected Three-way Switches is shown in Fig. 294. Note that three conductors project from each

three-way switch outlet, *S*, two of which, *F*, are the switch feed wires, and the third, *W*, is the lamp feed wire. Also note that two conductors, which are the lamp feed wires, *W*, project from the lamp outlet, *L*. The two switch feed wires at each outlet should be connected to the branch, *B*—one feed wire being connected to each branch wire.

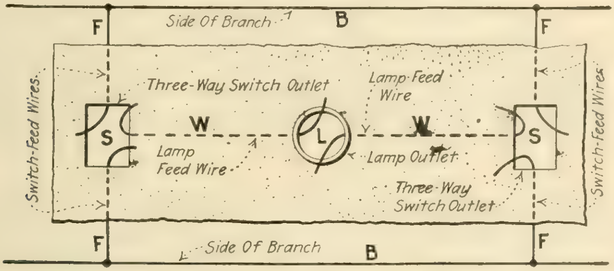


FIG. 294.—Showing conductor arrangement for Carter-connections of two-location lamp-control, employing two three-way switches, as it appears at the outlets before connection to the switches and lamps.

257. The Various Conductors At The Switch Outlets Of A Two-location Control Carter Circuit May Be Identified as follows: First, at each switch and lamp outlet, separate all projecting conductors from each other as indicated in Fig. 294. Then short-circuit (connect together) the branch wires, *B*, at the distribution center. Now proceed to a switch outlet (*S*, Fig. 294) and there connect various pairs of the projecting wires to the two magneto leads until a "ring" is obtained. The two wires which give the ring are the switch feed wires, *F*. The third wire is the lamp feed wire, *W*. Mark these wires for future identification and separate them from each other. Then repeat this same operation at the other switch outlet. The two conductors at the lamp outlet are, of course, the lamp feed wires.

NOTE.—THIS CARTER-CONNECTED TWO-LOCATION CONTROL CIRCUIT MAY THEN BE TESTED OUT as follows: (See Sec. 243 on "testing out" standard circuits). Remove the short-circuit from the branch wires at the distribution center and connect the magneto thereto. Now the magneto should not "give a ring." If it does, there is a short-circuit on the branches. This should be located and removed before further testing. Then wrap together the bared ends of the two feed wires (*F*, Fig.

294)—which have been previously identified and marked— at one switch outlet. If the magneto now rings, the switch feed wires at this outlet are properly connected. If the magneto does not ring, the switch feed wires at this location are probably connected to the same side of the branch circuit. This, of course should be corrected. Repeat the same operation at the other switch outlet. Then connect together the two conductors at L, and also the three conductors at one of the switch outlets, S. Disconnect the magneto from the branches, and at the other switch outlet, connect the end of W to one terminal of the magneto. Now when either one of the two-switch feed wires, which project from this outlet, is connected to the other magneto terminal, a "ring" should be obtained. Remove this switch feed wire and repeat with the other. If a "ring" is again obtained, the circuit is properly connected. The switches and lamps may then be installed.

258. For Three-location Carter-connected Control, The Arrangement Of Conductors Before Connecting To Switches And Lamps is shown in Fig. 295. With the exceptions noted

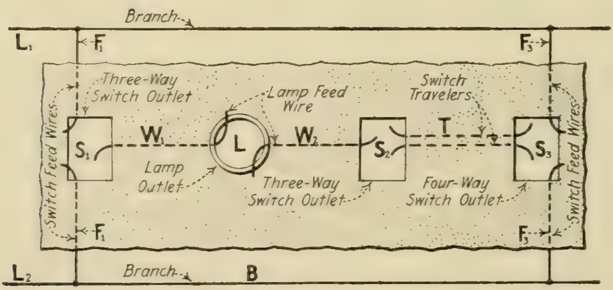


FIG. 295.—Showing conductor arrangement for Carter-connection of a three-location lamp control, employing two three-way switches and one four-way switch, as it appears at the outlets before connection to the switches and lamps.

below, the same number of conductors project from each of the outlets in the three-location control as in the two-location control (Sec. 257). The exceptions are that in the three-location control each four-way switch outlet (S_3, Fig. 295) has four conductors projecting therefrom—two switch feed wires, F_3, and two switch travelers, T.

259. The Identification Of The Various Conductors At The Switch Outlets Of A Three-location Carter-connected Control May Be Effected by substantially the same procedure as for that which is outlined in Sec. 257 for the two-location

control. However, the following differences should be noted: After identifying the conductors at S_1, Fig. 295, proceed to, and identify the feed wires, F_3, at switch outlet S_3. The other two projecting conductors are the switch travelers, T. Connect together the bared ends of the travelers, T, which project from S_3. Then, at S_2, those two wires which will "ring" the magneto are the switch travelers for that outlet. The third wire at S_2 is the lamp feed wire, W_2.

Note.—This Carter-connected Three-location Control Circuit May Then Be Tested Out by following the same principles as those which are outlined in the note subjoined to Sec. 257.

QUESTIONS ON DIVISION 5

1. For what applications are three- and four-way switches employed?

2. *Make a sketch showing diagram of connections of the following:*

a. A three-way switch used as a single-pole switch.

b. A four-way switch used as a single-pole switch.

c. Two-location control using two three-way switches.

d. Two-location control using two four-way switches.

e. A three-way switch circuit fed from different branches. If the three-way circuit is erroneously connected to the same side of the circuit, how may the error be easily rectified?

f. A three-way switch circuit which may be used when the switches are located near each other.

g. A typical wiring lay-out for a small residence which has two-location control of up-stairs and down-stairs hall lights. Also a diagram with three location control of the first and second-story hall lights. Also a similar diagram for four-location control.

h. Two-location control with one three-way switch and one four-way switch.

i. Two-location control with a single-pole, double-throw knife switch used with a three-way snap switch. When used with a four-way snap switch.

j. A three-way switch circuit with pilot lamps located at the switches to indicate whether the lamps in the lighting circuit are "on" or "off."

k. A two-location restricted control with four, three-way switches.

l. Four-location control for down-stairs and up-stairs hall lights using two three-way and two four-way switches.

m. Three-location control with three four-way switches.

n. Three-location control with two four-way switches and one single-pole, double-throw knife-switch.

o. A restricted switch circuit for hall lights.

p. A stairway lighting circuit whereby the stair landing on which one is standing, together with the one above or below, may be lighted. Explain its operation.

q. Three-way switch circuit for garage.

r. Remote control of a vacuum-cleaner motor.

s. Independent control of a vacuum-cleaner motor.

3. Explain with diagrams how the travelers, feed wires, return wires, and the proper branch-circuit wires of a multi-location-control circuit may, after installation, be identified and tested out with a magneto test set.

4. What is the *Carter system* of multi-location control.

5. What are some of its advantages and disadvantages? Make sketches to illustrate each.

6. *Make a sketch showing diagram of the Carter-system of connections of the following:*

a. Two-location control.

b. Three-location control.

c. Two-location control from two different branches. Explain what may happen if one of the branch fuses burns out.

d. Two different hallway or stairway circuits.

e. A combined restricted and selective circuit.

7. Explain, with a diagram, how to identify and "test out" the different conductors in a Carter-system circuit.

DIVISION 6

MASTER OR EMERGENCY CIRCUITS

260. A "Master" Or So-called "Emergency" Circuit, (Fig. 296) is one which is controlled by a master switch (Sec. 56). The most frequent application of master circuits is in residences to provide emergency lighting in case of fire or an attack by house-breakers. A master circuit may be utilized to light simultaneously: (1) *All of the lamps within a building,* Fig. 297. (2) *Lamps which are located on the outside of a building,* Fig. 298. (3) *All lamps on both inside and outside.* (4) *Certain designated lamps or lamp-groups.* Master circuits are sometimes called *burglar circuits.*

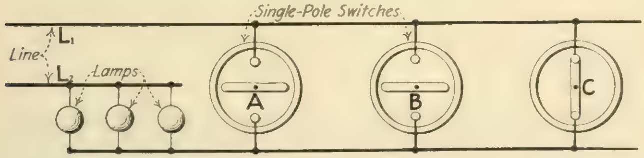


FIG. 296.—Elementary master circuit. (Either switch A, B, or C, may be considered as a master switch, since the lamps may be lighted by either switch, and no other switch on the circuit will extinguish them.)

NOTE.—REMOTE-CONTROL MASTER CIRCUITS—those which employ a solenoid-operated switch—are discussed in Div. 8.

NOTE.—THE TERM "LOCATION CONTROL" means control—the ability to light or extinguish the incandescent-lamp groups—by operating a switch or switches other than the master switch. Ordinarily, in master circuits, three- or four-way switches are used for location control. Usually these location-control switches are installed in the same room with the lamp group or near it—but they may be installed at any convenient point.

NOTE.—SOMETIMES, IN EMERGENCY SYSTEMS OF LIGHTING, IT HAS BEEN THE PRACTICE TO PROVIDE FOR THE EMERGENCY LIGHTS SEPARATE CIRCUITS AND SEPARATE FIXTURES IN ADDITION TO THOSE REQUIRED FOR THE NORMAL ILLUMINATION (W. S. Jones, in POWER PLANT ENGINEERING). This has resulted in a dual lighting system in

the spaces where emergency lights are required and, aside from the expense of such an arrangement, it has the added disadvantage that the

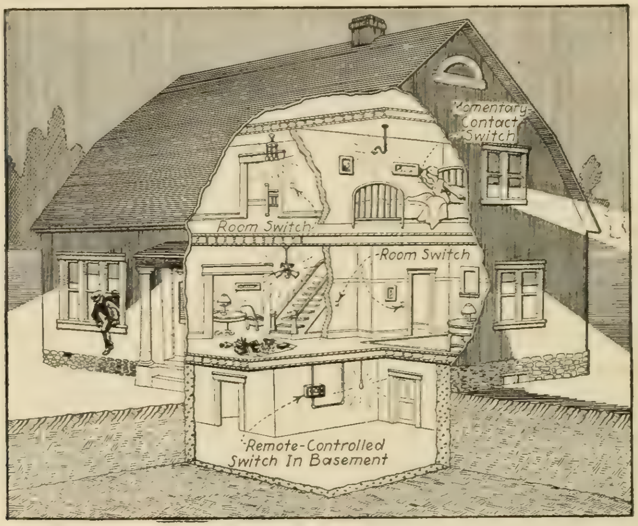


FIG. 297.—In an emergency all the lights in a house can be lighted simultaneously by a remote-controlled switch, which can be controlled by a momentary-contact switch. The momentary-contact switch can be located in any desired room. (Courtesy of *Hart Mfg. Co.*)

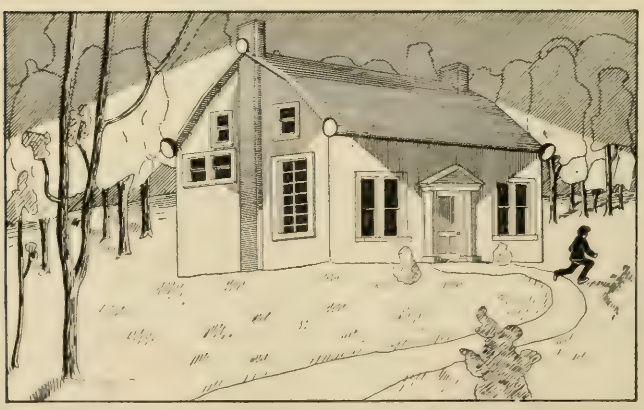


FIG. 298.—Lamps located on outside of residence controlled by master switch in owner's bedroom.

emergency circuit is not sufficiently used to be assured of proper operation when the emergency occurs. Frequently, such circuits have been out of

order several weeks or months and the trouble was not made evident until there was occasion for their use. But where the same lamps are used for both general and emergency lighting such difficulties are not likely to occur. Thus as the emergency lights are used normally every day as general lights any trouble with any one of the lights will make itself apparent immediately and the trouble will, as a rule, be remedied at once.

NOTE.—EMERGENCY OR MASTER CIRCUITS ARE FREQUENTLY SPECIFIED FOR RESIDENCE-WIRING INSTALLATIONS. Where they have not been specified by the architect, the contractor can often induce the owner to install them if he explains their advantages. In this way, it is often possible for a contractor to obtain a fair profit on an installation that otherwise would offer but meager returns.

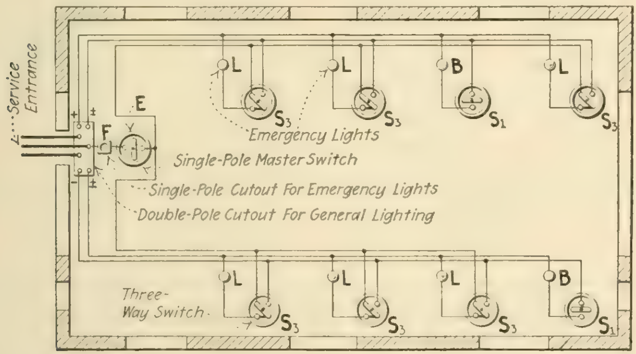


FIG. 298A.—Emergency lighting in a fire-engine house. No special fixtures are required. The lights, L, which are used as both emergency lights and general lights, are each controlled by a three-way switch, S_3. The master switch, E, which controls the emergency lights, is a standard single-pole flush switch located at the operator's desk. General lights are shown at B. The switches S_1 are single-pole switches.

The *master switch* (Sec. 56) is usually placed in the owner's bedroom—often near the head of the owner's bed. He can thereby light simultaneously at will, all of the lamps, or only certain designated lamps, in his residence. Whether the operation of the master switch will light all of the lamps or only part of them is determined by the circuit arrangement which is employed. This he can do regardless of the positions of other switches throughout the building controlling the same lamps.

NOTE.—MASTER CIRCUITS ARE FREQUENTLY USED AT FIRE DEPARTMENT STATIONS (Fig. 298A). The master switch is installed in the operator's room. The lamps on the master circuit are located in the dormitories, corridors and apparatus rooms. When a call is received during the night the attendant at the operator's desk may instantly light the lamps throughout the station house.

261. Master Circuits May Be Classified According To Their Operating Features as follows: (1) *Straight, or straight-control master circuits,* Fig. 299 (Secs. 265 to 276) wherein the master switch will, when operated, only light the lamps which are on the master circuit. (2) *Universal, or universal-control master circuits,* Fig. 324, wherein the master switch, can be operated, to either light or extinguish all of the lamps which are on the master circuit; see Secs. 277 to 283.

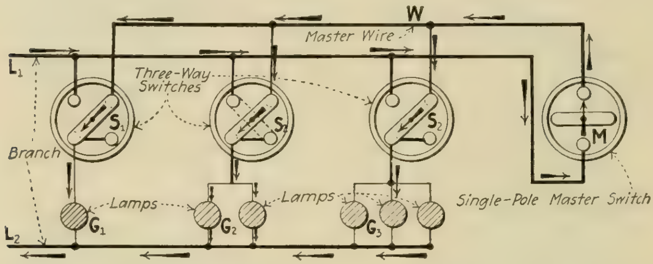


Fig. 299.—A simple emergency or master circuit. (Each lamp group has only one control location. Single-pole switch, *M*, is used for master switch. All lamps are connected to one branch circuit.)

Explanation.—By Means Of A Straight-control Master Circuit, a person may so operate the master switch that all of the lamps on the circuit will be lighted, irrespective of the position of any other switch or switches on the circuit. However, a straight master switch can only be operated to extinguish such lamps as happen to have their individual switches in the open position. *With a universal-control master circuit*—usually controlled by two separate switches mounted at the same location—all of the lamps may be lighted or extinguished at will, irrespective of the positions of the individual-lamp-circuit switches.

262. Master Circuits May Be Further Classified According To The Installation Features in regard to: (1) *The number of wires of the system which supplies the energy;* that is, whether the energy is supplied by a two-wire or by a three-wire system. (2) *The number of control-locations with which the individual lamp-groups are provided;* that is whether single- or multi-location. (3) *The type of master switch used;* see note below. (4) *The system of connections employed for the three- and four-way switches which control the individual lamp-groups;* that is, whether Carter or standard (Sec. 249). Master-circuit wiring

diagrams which embody various combinations of the above classifications are described in the following sections.

NOTE.—THE VARIOUS TYPES OF SWITCHES WHICH MAY BE USED AS MASTER SWITCHES: (1) *Single- or multi-pole switches*, of either the knife-blade, rotary-snap, or push-snap type. (2) *Three- and four-way switches.* (3) *Momentary-contact switch in conjunction with a solenoid-operated switch* (see Div. 8).

263. To Insure Positive Operation Of A Master Circuit, Keyless Sockets Should Be Used At All Lamp Outlets which are connected to the emergency circuit. Also, the sockets should be of a type in which the lamps can be locked. It is obvious that if a key socket is open, or if the lamp be unscrewed from the socket, it cannot be lighted by closing the master circuit. Thus, in every room where positive master-switch control is desired at all times, there should be connected to the master circuit at least one lamp which is equipped with a keyless socket into which the lamp is locked.

264. To Comply With Code Requirements In Master-circuit Wiring, the master wiring must be so divided and fused that the maximum load which may be carried by any master wire and its protecting fuse will not exceed that which is permissible (Secs. 172 and 174) on an ordinary branch circuit. That is, the master wire (W, Fig. 299) and its protecting fuse are considered as one side of a branch circuit, insofar as the maximum load which may be imposed on it is concerned. Thus, a single master wire must not serve more than 16 sockets 660 watts—or in special cases 32 sockets or 1,320 watts.

NOTE.—ALTHOUGH THERE IS NO SPECIFIC REFERENCE TO MASTER SWITCHES IN THE CODE, there is no limitation as to the number of switches that may be placed in any installation. Hence master switches may be installed without violating CODE requirements. However, as above suggested, where a master switch controls an incandescent lighting load greater than 660 watts, the load must be divided on the load side of the master switch between several master wires and each must be protected by fuses, so that no master wire will carry more than 660 watts. See Sec. 172.

265. Single-location-controlled Lamps On One Branch Circuit May Be Straight-mastered as shown in Fig. 299. This is the method which is ordinarily used in small residences or

apartments wherein there is only one branch circuit. Each lamp-group, G_1, G_2, and G_3, is provided with only one control-location, by the three-way switches, S_1, S_2, and S_3. The master switch, M, is a single-pole switch. With M and the three-way switches open as in the diagram, all lamps are off. However, by closing M, all lamps will be lighted, the current-path being as indicated by the arrows. Also wth M closed, if one of the switches, as S_2, is operated so that the switch-blade is moved to the dotted position, then the lamps, G_2, will remain lighted by current which will flow directly from L_1 through the switch S_2 and lamps G_2 to L_2. Thus all the lamps remain lighted when M is closed irrespective of the three-way switch blade positions.

266. Another Arrangement Of A Straight Master Circuit For Single-location-controlled Lamps is shown in Fig. 300.

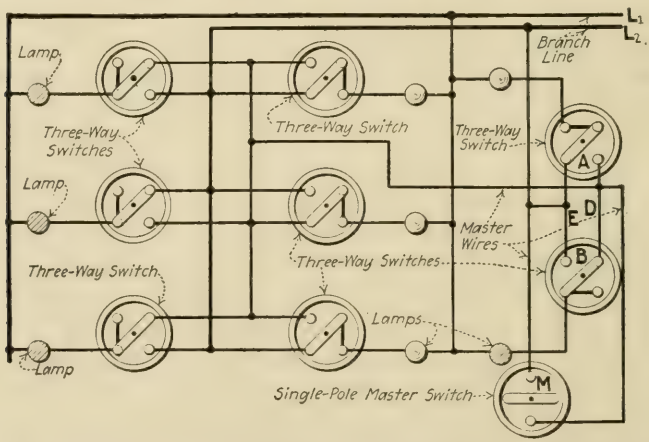


FIG. 300.—Emergency circuit for single-location controlled lamps which are connected to one branch circuit.

By tracing out the connections, it will be noted that one side of each lamp is connected to the same side, L_1, of the branch. The other side of each lamp is connected to one of the shunted terminals of the three-way-switch. The other two terminals on the switch are connected, one to the other side, L_2, of the branch, and one to the master wire. The two wires which connect switches A and B should not be mistaken for switch

travelers; they are not, because wire *D* connects one of the binding-posts of each *A* and *B* to the master wire, and wire *E* connects the other binding-post of each *A* and *B* to L_2. A single-pole switch, *M*, is used to control the master circuit.

267. A Straight Master Circuit For Single-location-controlled Lamps On Three Branch Circuits may be controlled by a single-pole master switch, M_1, as shown in full lines in Fig. 301. The same master control is provided herein as that

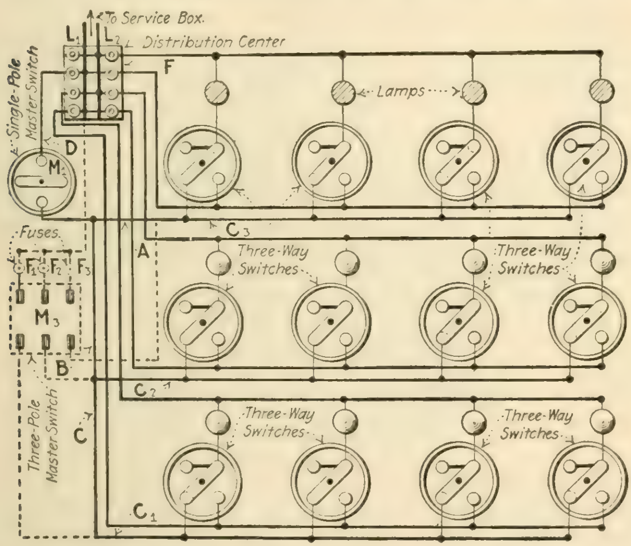


Fig. 301.—Emergency circuit for single-location-controlled lamps for three branch-circuits.

which was described in Sec. 265 for Fig. 299. It should be noted that if M_1 is closed when all of the lamps have been extinguished by their individual three-way switches, the current for lighting all of the lamps will be carried by one fuse, *F*. This will not be objectionable if the total number of sockets which are served by the three branches does not exceed 16 (see Sec. 264).

Note.—If The Total Number Of Sockets Does Exceed 16, an installation according to the diagram as shown in full lines (Fig. 301) may (Sec. 264) be contrary to the Code. If it develops that the installation is not in compliance with Code requirements, it may be corrected

by the following: Remove the switch M_1 (Fig. 301), and conductors, A, B, C, and D, and substitute therefor the three-pole fused switch, M_3, and the conductors which are shown in dotted lines. This provides a fuse, F_1, F_2, and F_3, for each of the master wires, C_1, C_2, and C_3. The maximum current which will then flow through any fuse will not exceed that which flows through any one branch. See Sec. 172.

268. Two Or More Branch Circuits May Be Interconnected Through A Master Circuit With No Adverse Results as shown in Figs. 302 and 303. As explained in the preceding section,

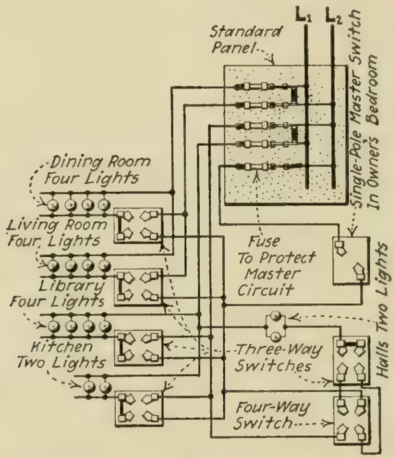


Fig. 302—Master switch circuit feeding from a two-wire panel board, flush switches being used. This arrangement must not be used where the master switch controls over 16 sockets or 660 watts. (*Bryant Electric Co.*)

interconnection violates Code requirements if the total interconnected load exceeds 16 sockets or 660 watts. In Fig. 302 two branch circuits, which serve a combination of one- and two-location-controlled lamp-groups, are interconnected through the master circuit. The single-pole master switch, M, operates to light all lamps shown in the diagram. Figure 303 shows four branch circuits. The two branches on the left of the illustration are interconnected one with the other; also the two on the right are interconnected. Each of the two pairs of branches which are interconnected are served through the emergency circuit by one blade of the double-pole master

switch, M. Hence not more than 16 sockets can be supplied by either of the master-circuit fuses, F. This is (Sec. 264) in compliance with CODE requirements.

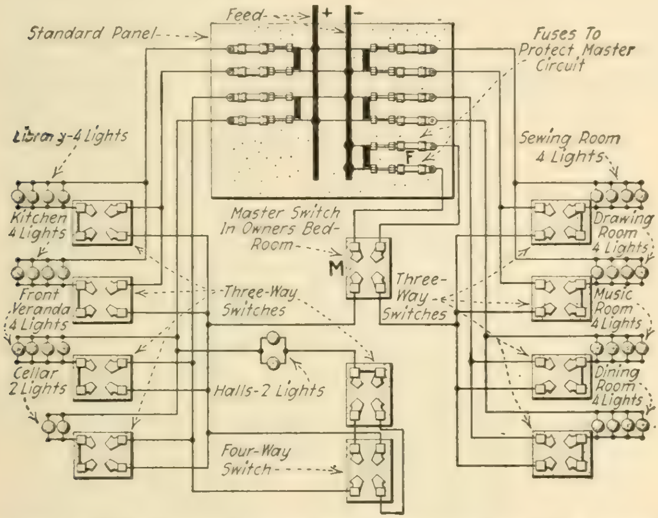


FIG. 303.—Master switch circuit feeding from a two-wire panel board, flush switches being used. This arrangement may be used where the master switch controls a maximum of 32 sockets or 1,320 watts. (*Bryant Electric Co.*)

269. A Stairway Straight Master Circuit is shown in Fig. 304. Individual single-location-control of the lamps on each floor is provided by the three-way switches, S_1, S_2, and S_3. The single-pole master switch, M, is located in the basement so that it may be conveniently operated by the janitor. Thus, all of the stairway lamps may, by closing M, be kept lighted. Or, if M is opened, the lamps on any floor may be lighted or extinguished by the switch which is on that floor.

270. A Method Of Installing A Straight Master Circuit In A Building Which Has Already Been Wired is outlined in Fig. 305. As shown, only one control-location is provided for each lamp-group. Three-way switches are substituted for the originally-installed single-pole switches. The dotted lines represent the additional wiring which is necessary to provide the master circuit. A double-pole switch, M, is used as a master switch. If M is closed, all of the lamps will be lighted.

If M is open, the lighting and extinguishing of any lamp-group may be controlled by its three-way switch. As drawn (Fig. 305), the master-switch connections render each branch circuit separate from and independent of the other. However, as will be noted by tracing out the connections, if conductors A and B are interchanged on the master-switch binding-posts, some of the lamps on both branch circuits may, if a fuse rup-

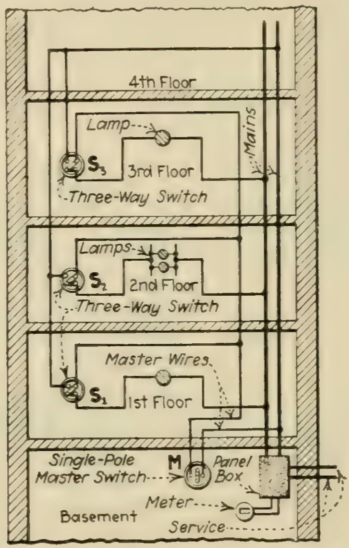


FIG. 304.—A stairway master circuit. (Master switch M is located in the basement; when M is closed the lamps on all floors are lighted and cannot be extinguished by operating the three-way switches.)

tures, burn at one-half normal voltage when M is closed. If so desired two single-pole switches—one for each branch circuit—could be used to control the master circuits.

271. The Usual Method Of Providing A Straight Master Circuit For Two-location-controlled Lamp-groups is shown in Figs. 306 and 307. The two-location control for the lamp-group, G, (Fig. 306) is obtained by one three-way switch, T, and one four-way switch F. The master switch is a single-pole switch, M. As suggested in Fig. 308, this method of connection may be extended to include any number of lamp-groups which may be connected to one branch circuit. If it is

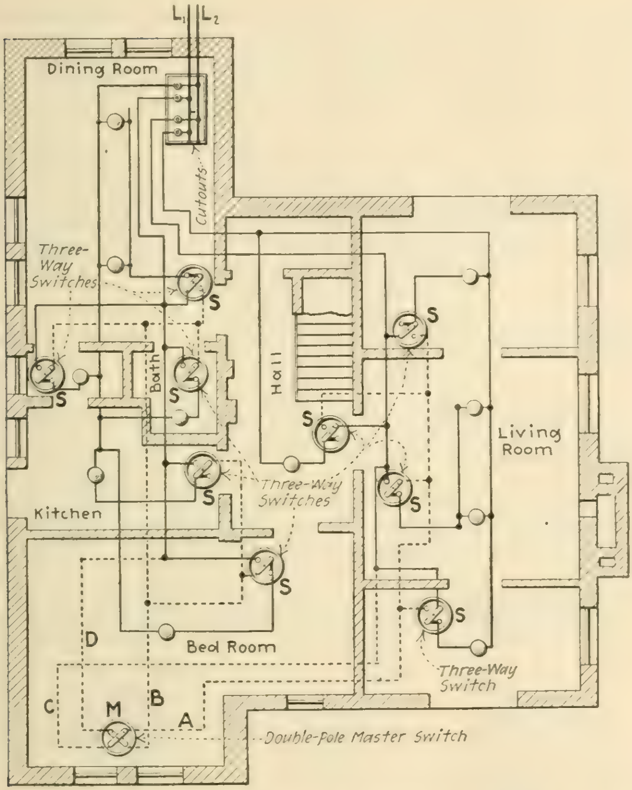


FIG. 305.—Showing method of installing an emergency circuit in a building which has already been wired. (Three-way switches, *S*, are installed in the original single-pole switch outlets. Dotted lines indicate the necessary additional wiring.)

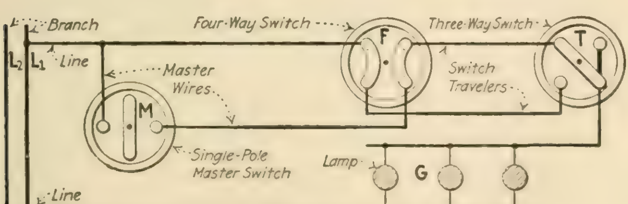


FIG. 306.—Simple master circuit for one lamp-group which is provided with two-location control.

desired to master more than one branch circuit, as many single-pole master switches may be used as there are branches to be mastered. Or, a double-pole switch wired as two single-pole switches (Fig. 309); a three-pole switch wired as three single-

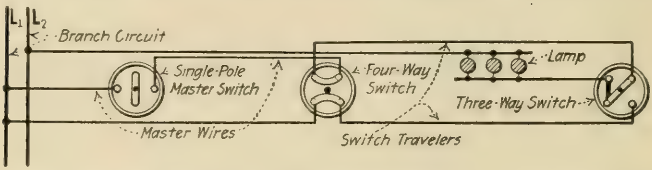


Fig. 307.—Straight-control master circuit for two-location controlled lamps. (Two-ocation control of the lamp-group is obtained by a three- and a four-way switch.)

pole switches; a four-pole switch wired as four single-pole switches, and so on, can be used.

Explanation.—The connections for the above method of mastering may be outlined as follows: Connect one side of each lamp-group (*G*, Fig. 308) to one side of the branch, L_1. Connect the other side of *G*

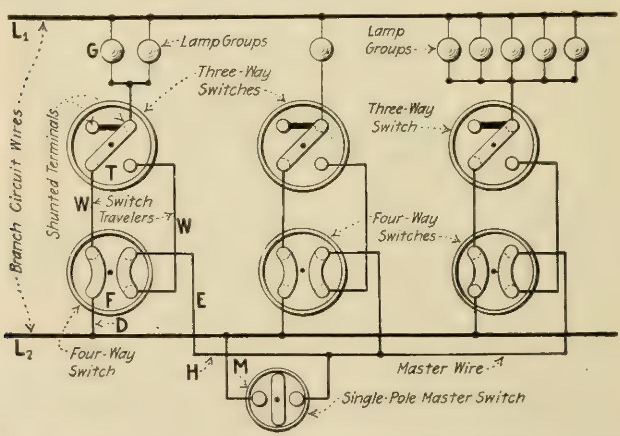


Fig. 308.—Straight-master circuit for several two-location-controlled lamp-groups on the same branch circuit, using a single-pole master switch.

to one of the shunted terminals (usually marked "L" on the switch) of the three-way switch, *T*. The switch travelers, *W*, have one pair of their ends connected to the other two binding-posts of *T*. The other two ends of *W* are connected to diagonally-opposite binding-posts of the four-way switch, *F*. A wire, *D*, is connected; one end to

either of the other two binding-posts of F, and the other end to the branch, L_2. Another wire, E, is connected between the remaining-unwired binding post of F to the master wire, H. The single-pole master switch, M, is connected, one terminal to H and the other terminal to L_2.

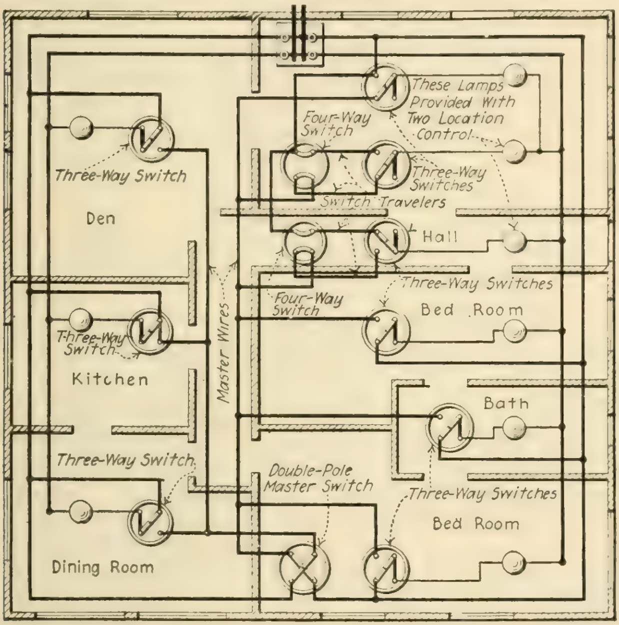


FIG. 309.—Wiring diagram of emergency circuit for small residence wherein all lamps are on the emergency circuit.

272. A Straight Master Circuit For One- And Two-location-controlled Lamps Which Are Connected To The Same Branch Circuit is illustrated in Fig. 309. Such an installation typifies that of the medium-size residence, wherein two branch circuits are employed. The double-pole master switch, M, is wired as two single-pole switches. Interconnection between the two branches through the medium of the master circuit is thereby prevented. Actually, this installation contains two separate and distinct master circuits—one for each branch. The principle of connections used in Fig. 309 is a combination of that described in Sec. 265, Fig. 299, with that of Sec. 271, Fig. 308.

273. Various Methods Of Providing A Straight Master Circuit For A Single Group Of Multi-location-controlled Lamps, Using A Single-pole Master Switch are shown in Figs.

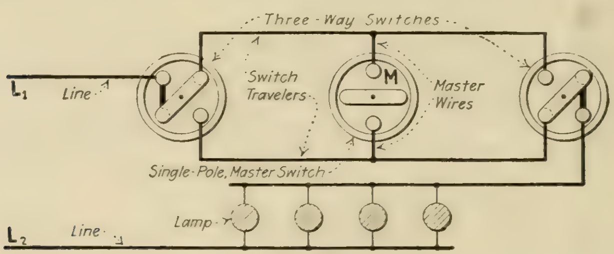


Fig. 310.—Straight master circuit for two-location-controlled lamp-group, wherein the two control-locations are provided by two three-way switches.

310, 311, 312, and 313. Such arrangements are, generally, applicable only for hallway or stairway circuits where master

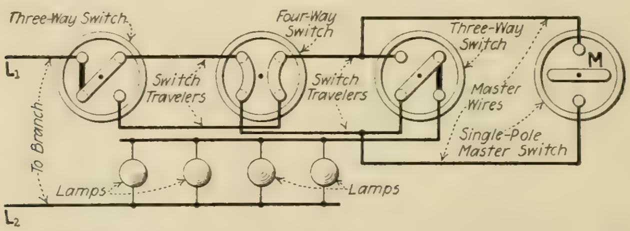


Fig. 311.—Straight mastering of three-location-controlled lamp-group. (Control-locations provided by two three-way and one four-way switch.)

control for only one lamp-group is desired. In Fig. 310, the master switch, *M*, a single-pole switch which is connected

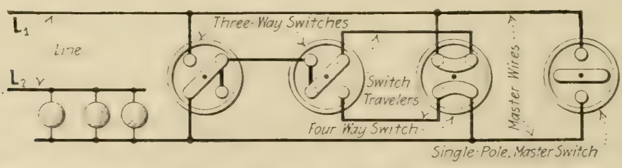


Fig. 312.—Single-pole master switch connected in parallel with one four-way and two three-way switches.

across the travelers, when closed, short-circuits the switch travelers and holds them closed against either of the three-way switches. As shown in Fig. 311, a three-or-more-location-

controlled lamp group may be mastered by connecting the master switch across the switch travelers between any two of the control locations. In Fig. 312, the three-location-control of the lamp-group is effected by two three-way switches and

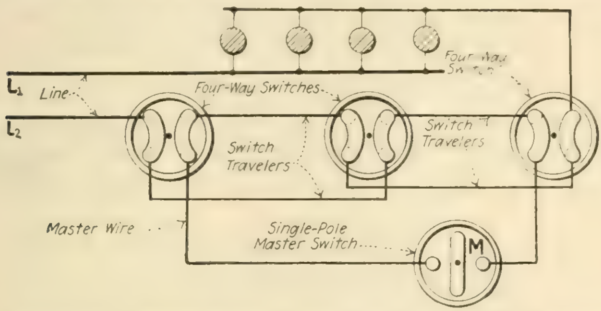


Fig. 313.—Emergency circuit for a three-location-controlled lamp group wherein each control-location is provided by a four-way switch.

one four-way switch. In Fig. 313, three four-way switches are utilized to provide the three-location control for the lamps. Compare Fig. 313 with Fig. 257 and note that the master wires in Fig. 313 are connected to the idle binding-posts of the end-switches of Fig. 257.

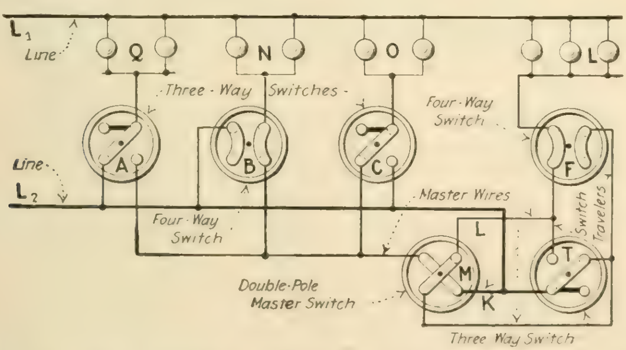


Fig. 314.—Straight mastering of combination one- and two-location-controlled lamps with a double-pole master switch. (One blade of M is used to short-circuit the switch travelers.)

Note.—Straight Master Control Of A Two-location-controlled Lamp-group, L, By Short-circuiting The Switch Travelers may be obtained as diagrammed in Fig. 314. When the master switch, M, is closed the switch travelers between F and T are short-circuited

through one blade of M and the wires, K and L. The single-location-controlled lamp groups, Q, N and O, individually controlled either by three-way switches, A and C, or by a four-way switch, B. As shown, the double-pole master switch is wired as two single-pole switches. When M is open all of the lamp groups shown are controllable by their respective "location" switches. When M is closed all of the lamp groups shown are lighted, irrespective of the positions of the location switches.

274. A Straight Master Circuit For Two Or More Lamp-groups Wherein One Or More Of The Lamp-groups Is, By Two Three-way Switches, Provided With Two-location Control (Figs. 315, 316, and 317) must be equipped with one

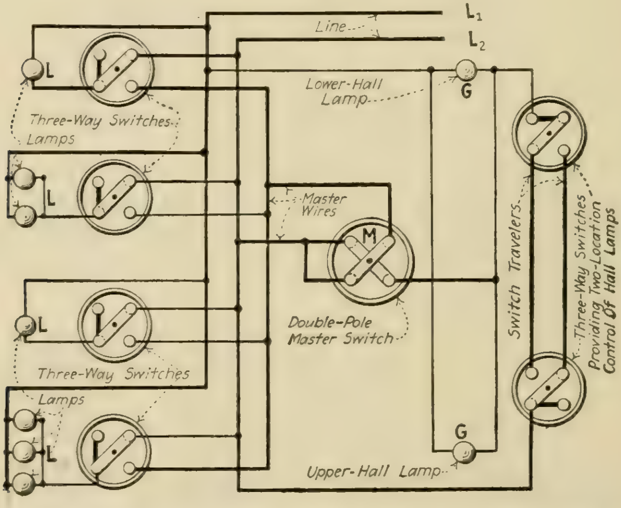


Fig. 315.—Double-pole master switch wired as two single-pole switches for the emergency lighting in a combined one- and two-location controlled installation.

single-pole master switch for all of the single-location- controlled lamp-groups, and with one additional single-pole master switch for each lamp-group which has three-way switch two-location control. In Fig. 316, the master switch, M_1, controls the emergency circuit for the single location-controlled lamps, L. M_2 controls the emergency circuit for the three-way-switch two-location-controlled lamp-group, G. In Figs. 315 and 317, the same result is effected by wiring the double-pole switch M as two single-pole switches.

EXPLANATION.—Figure 318 illustrates why the above specified switching must be employed. In Fig. 318 one single-pole master switch, M, is used. When M is closed all the lamps will be lighted. But when M is

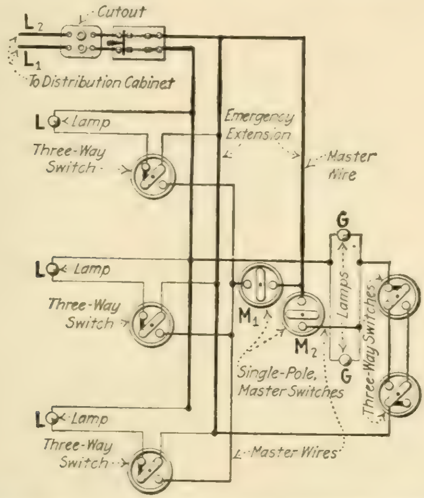


FIG. 316.—Two single-pole master switches used to control an emergency circuit for combined one- and two-location-controlled lamps.

open, lamps A, B, and C cannot be extinguished by their respective switches, unless switches E and F are operated to extinguish group D. With the switch bars in the various positions as shown in Fig. 318, group

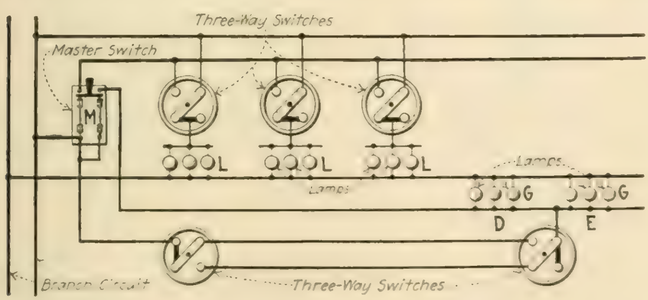


FIG. 317.—Double-pole knife switch as master switch for emergency lights, in a combined one- and two-location-controlled installation.

C should be extinguished but actually is not. Since current can follow the path indicated by the arrows, C will be lighted. If switch H is operated to the position corresponding to that of G, lamps C will still

be lighted. Thus, lamp-groups A, B and C may be controlled by their respective switches only when either E or F is operated to extinguish D.

275. Master Circuits For Two Branches Which Serve A Combination Of One- And Two-location-controlled Lamps are shown in Fig. 319. Since all of the lamps on the branch, XY, which serves the left-hand side of the house are provided with only single-location control, a single-pole switch, M_1, may (Sec. 265) be used as a master switch. The right-hand branch, VW, has connected to it a lamp-group which is provided with two-location control by the two three-way

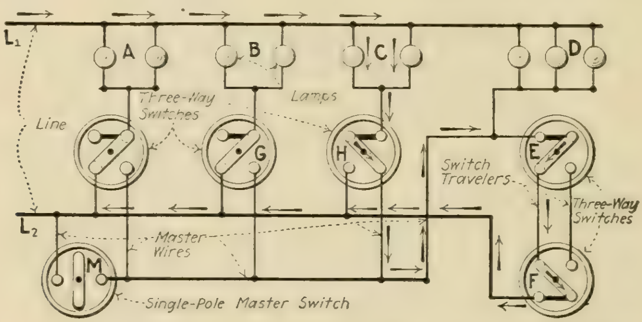


FIG. 318.—Incorrect master circuit. (Lamps A, B, and C, cannot be extinguished except when lamps D are extinguished.)

switches, A and B. Therefore the master switch which controls the emergency circuit for this VW branch must (Sec. 274) be provided with two switch poles. These two switch poles are obtained by wiring the double-pole switch, M_2, as two single-pole switches. Thus, by using two master switches, M_1 and M_2 no interconnection between the two branches will result; really three master switches have been used because, M_2 is, in effect, two single-pole switches.

NOTE.—WHERE A COMBINATION OF ONE- AND TWO-LOCATION-CONTROLLED LAMP-GROUPS ARE CONNECTED TO THE SAME BRANCH CIRCUIT (Figs. 309, 315, 316, 317, 319, and 320), it will usually be more economical to use, for the two-location-controlled lamp-groups, one three-way switch and one four-way switch, connected as shown in Figs. 308 and 309, than to use two three-way switches connected as shown in Figs. 315, 316, 317, and 319. The arrangements of Figs. 308, 309, and 320, require only one single-pole master switch for each branch which is provided with

an emergency circuit. Since the average-size residence does not usually have more than three branches, one three-pole master switch can generally be used to control the entire emergency-circuit system. Whereas, if the wiring is made in accordance with Figs. 315, 316, 317, or 319, several master switches and a large additional quantity of wire may be required.

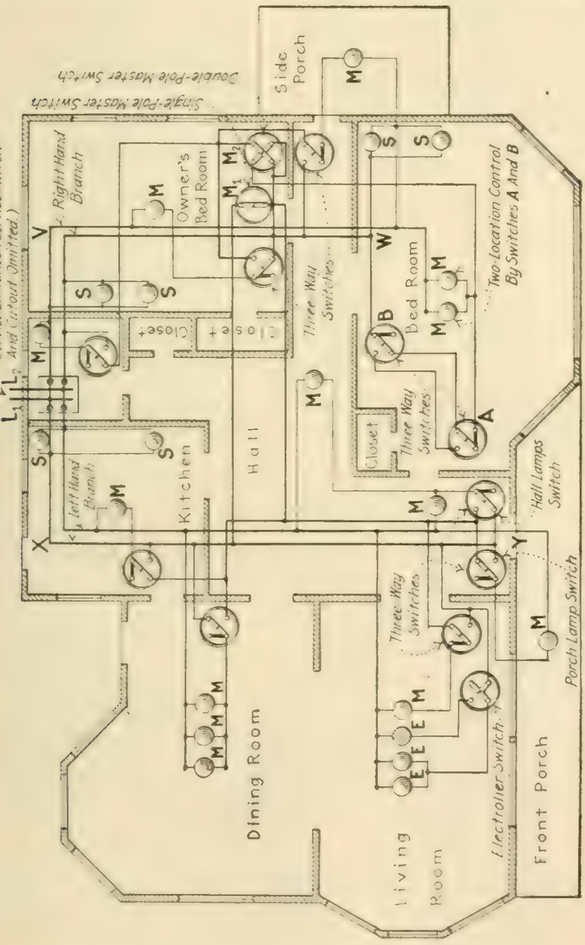


FIG. 319.—Master-circuit wiring diagram for one-story residence. (Lamps *M* are on master circuit; lamps *E* on electrolier switch; lamps *S* controlled by key sockets.)

276. If It Is Desired That Only A Part Of The Lamps In An Installation Be Connected To The Master Circuit, the wiring may be arranged similarly to that of Fig. 319. The lamps, *S*, (Fig. 319) which are controlled by key sockets or single-

pole switches (not shown in the illustration) are not connected to the master circuit, and consequently will not, necessarily, be lighted when the master switches are closed. Such provision of lamps, which are not on the master circuit, may result

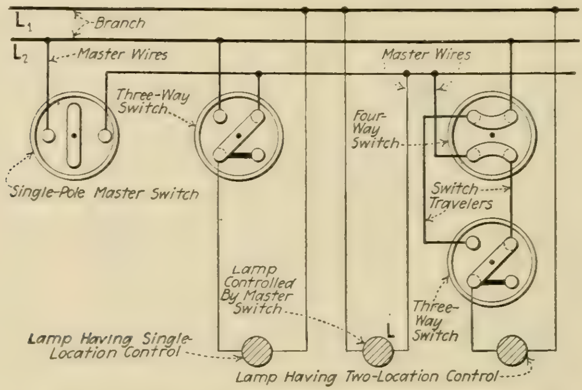


FIG. 320.—Single-pole master switch controlling the emergency circuit for a combination of one- and two-location-controlled lamps. (Lamp L is lighted only when master switch is closed.)

in a reduction of the wire- and switch-cost. Yet, since there are, in every room, lamps which are on the master circuit, the installation is equally as effective for burglar protection as though all of the lamps in it were on the master circuit.

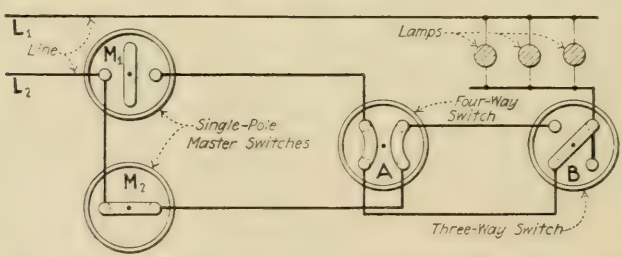


FIG. 321.—Simple universal master circuit. (Both M_1 and M_2 open, all lamps off. Both closed, all lamps on. Either M_1 or M_2 open and the other closed, lamps controlled by A and B.)

277. The Principle Involved In The Connections Which Are Ordinarily Used To Obtain Universal Control Of A Master Circuit (Sec. 261) may be understood by a consideration of Fig. 321. Two master switches are necessary. If both

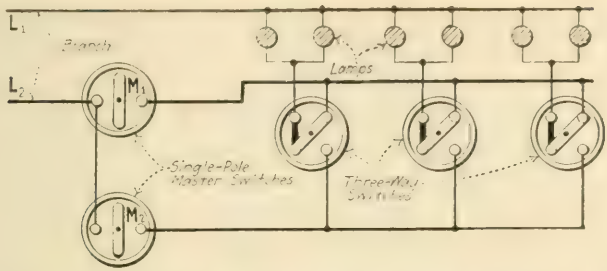


FIG. 322.—Universal mastering of single-location-controlled lamp-groups using two single-pole master switches.

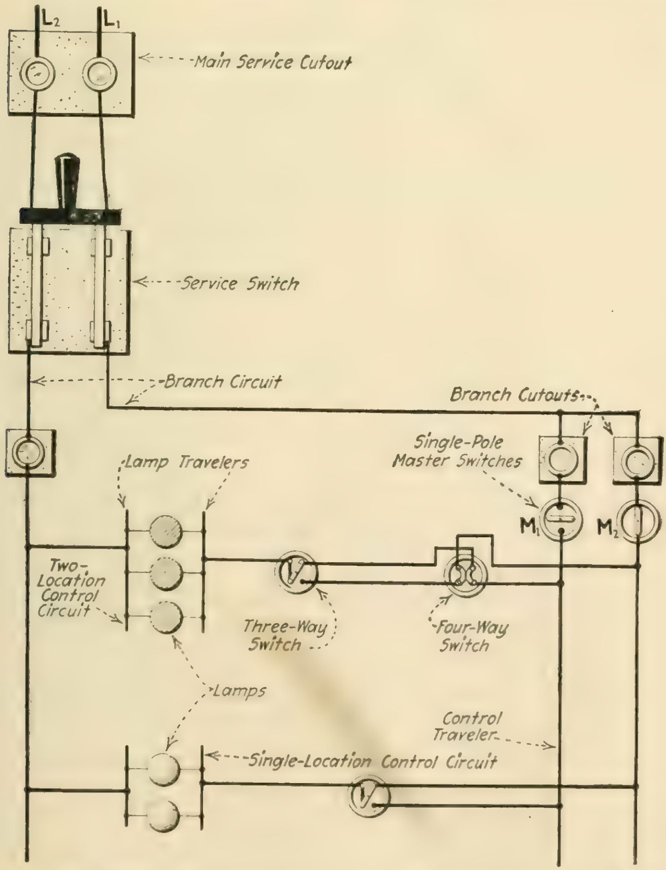


FIG. 323.—Elementary wiring diagram of a universal-control master circuit.

of the master switches, M_1 and M_2, are open, only one side of the lamps can be connected to the line, L_1. Consequently, the lamps will not burn while both M_1 and M_2 are open. If both M_1 and M_2 are closed, the lamps will be connected to both L_1 and L_2 through switches A and B, irrespective of the positions of A and B. Therefore, the lamps will, while both M_1 and M_2 are closed, always be lighted. If either M_1 or M_2 is closed and the other open, the lamps may then be lighted or extinguished by either A or B. In Fig. 322, the operation is the same, except that each of the lamp-groups is provided with only one control location.

Note.—Another Elementary Universal-control Master-switch Circuit is shown in Fig. 323. For a universal-control circuit two single-pole master switches M_1 and M_2, are used in each branch circuit. That is, each pair of single-pole master switches can control a group of sockets not exceeding sixteen in number and requiring not more than 660 watts. If the master circuit controls more than sixteen sockets, or 660 watts, it will be necessary to install a set of branch cutouts and one additional pair of single-pole master switches for each sixteen sockets or 660 watts, or portion thereof, so that the Code requirements may be satisfied.

Note.—A Residence Can Seldom Be Wired In Exact Accordance With The Elementary Circuit shown in Fig. 323, because this wiring diagram is drawn for only one branch circuit. In cases where the lamps are supplied with energy from more than one branch circuit and must be subject to master-switch control, the wiring becomes more complicated. The connections can be very readily made for any number of branch circuits, provided the wireman remembers and follows the few simple rules which are given in Sec. 279.

278. A Diagram Of A Universal-control Master Circuit For Combined One- And Two-location-controlled Lamps is shown in Fig. 324, also in Fig. 325. The principles involved in these diagrams will usally be found applicable to medium-sized residences which are wired with two branch circuits. In Fig. 324, the single-pole master switches, C and D, provide universal control for one of the branch circuits. E and F provide universal control for the other branch. The operation of master switches C and D, and of E and F, produces the same results on their respective branches as that which was explained in Sec. 277. In Fig. 325, except for the master switches, the wiring is the same as that in Fig. 324. In Fig. 325, the two double-pole master switches, M_1 and M_2,

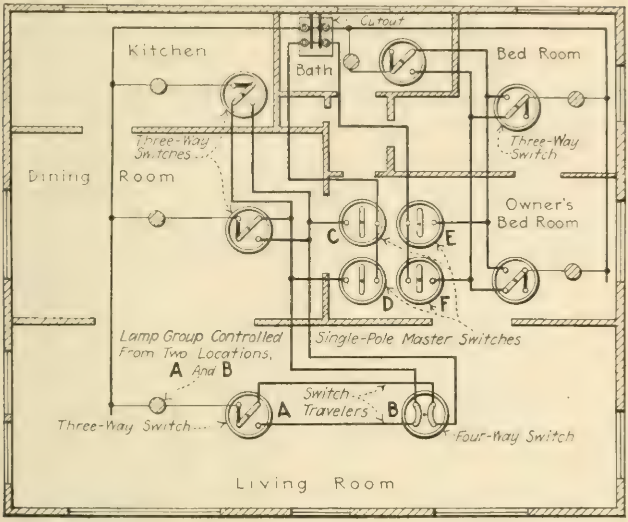


Fig. 324.—Four single-pole master switches control the universal emergency circuit for two branch circuits.

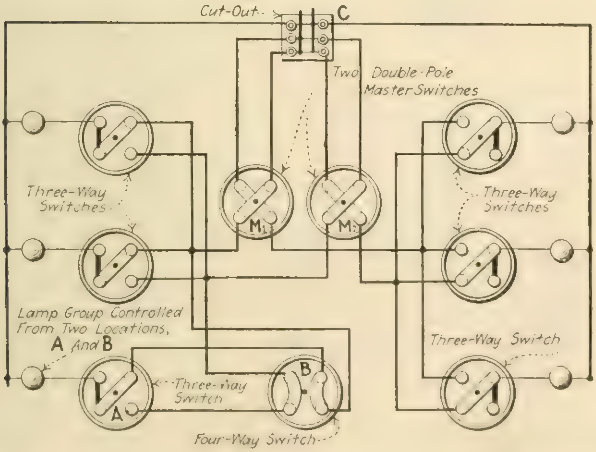


Fig. 325.—Two double-pole master switches control the universal emergency circuit for two branch circuits.

are wired as four single-pole switches, so that: (1) *When both switches are closed,* all lamps are lighted. (2) *When both switches are open,* all lamps are extinguished. (3) *When one switch is open and the other closed,* the lighting of the lamps is controlled by their respective individual-controlling switches.

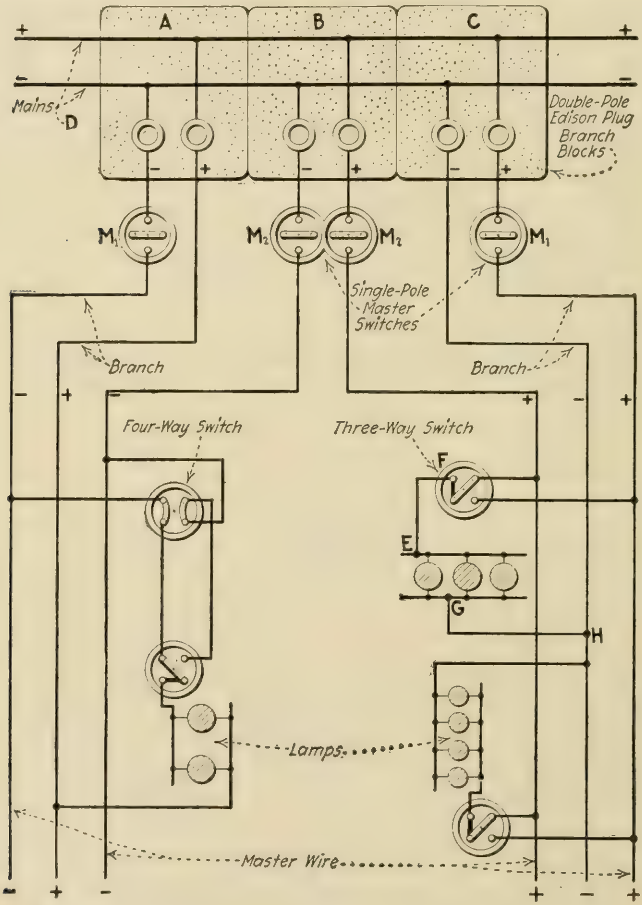


Fig. 326.—Universal-control master-circuit wiring with plug cutouts.

279. The Method Of Wiring For Universal-control Master Circuits Where Porcelain-base Edison Plug Cutouts Or Branch Blocks Are Used is illustrated in Fig. 326. Two branch circuits are shown. One is fed through the cutout *A*,

and the other through C. The cutout B is placed to carry the fuses for the master wires, shown in dotted lines in the diagram, for the two circuits. In laying out and wiring these circuits it will be convenient to designate one leg of the main circuit the *positive* or (+) leg, and the other the *negative* or (−) leg, as shown at D in Fig. 326. These legs need not actually be the positive and negative legs of the circuit, but these polarities are assigned to them arbitrarily merely to distinguish one side of the circuit from the other as an aid in tracing out connections.

EXPLANATION.—It will be noted from a study of Fig. 326 that each individual-control switch, whether it be a three-way or a four-way switch, has one of its terminals connected to a master wire, and another terminal connected with a side of the branch of the same polarity as the master wire for the same switch. The suggestion just noted is the most important one, and if the wireman follows it closely he will have little difficulty in connecting his circuits. One side of each group of lamps is always connected to the single terminal of a three-way switch, as shown at E and F in Fig. 326, while the other side of each group of lamps is connected always to a side of the branch of the opposite polarity to that of the master wire, as shown at G and H.

NOTE.—THE WIRING SCHEME SUGGESTED IN FIG. 326 CAN BE EXTENDED TO SERVE AS MANY CIRCUITS AS DESIRED, provided that each branch circuit does not contain more than sixteen sockets, nor be loaded with more than 660 watts. There should be a pair of single-pole master switches for each branch circuit.

280. In Universal Master Circuits Multi-pole Knife Switches Can Be Used Instead Of A Number Of Single-pole Snap Switches. Each blade of such a knife-switch would take the place of a single-pole flush or snap switch. For example, if there were three branch circuits in an installation, two triple-pole, single-throw knife switches would be installed. Each of the blades of one of these triple-pole switches would take the place of an M_1 switch (Fig. 323) while each of the blades of the other triple-pole switch would serve in place of an M_2 switch. Where multi-pole knife switches are used as suggested, the owner can light or extinguish all of the emergency-circuit lamps in his building by throwing the handle of one of these multi-pole switches.

281. A Building Which Is Already Wired For Electric Lamps May Be Provided With A Universal Master Circuit As

Suggested in Fig. 327. This diagram shows the circuits for such an installation where panel boxes have been installed. All of the master wires can be fed from one side of the circuit, the negative side, for example, as shown in Fig. 327. Single-pole cut-outs are used to protect the master wires from exces-

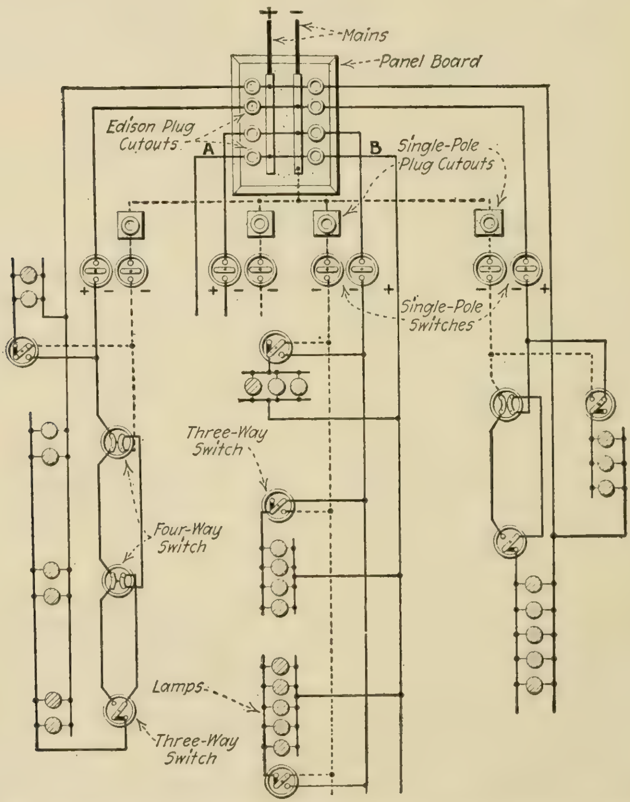


FIG. 327.—Universal-control master-switch wiring for an existing panel-box installation.

sive currents. These plug cut-outs are most conveniently placed at some point adjacent to the panel-box location as outlined in Fig. 327. The dotted lines in Fig. 327 indicate the wires that must be added to an existing installation to provide the universal control. At each location where a single-pole switch was formerly used in the existing installation, a three-

way switch must be installed, as shown. At certain points where three-way switches were formerly installed, four-way switches must be used. At certain other points where there were formerly four-way switches, the four-way switches are permitted to remain. Reference to Fig. 327 will make the meaning of this statement clear.

282. Where Branch Circuits Are Fed From A Panel Box the wireman may experience trouble in making the correct connections unless the suggestions given in Sec. 279 in regard to *polarities* are closely followed. It is frequently necessary to cross the conductors, as shown at *A* and *B* in Fig. 327, to make these polarities correct. This crossing is necessary because of the method in which connections are often made to the branch circuits on the panelboard. Inasmuch as master switches are usually installed in the owner's bedroom, it is best to install the panelboard in this room, or near it, so that the master switches will be near the distributing cabinet or panel box.

283. Universal Mastering Of A Lamp-group Which Is Provided With Multi-location Control May Be Effected By Using The Carter System Of Three- And Four-way Switch

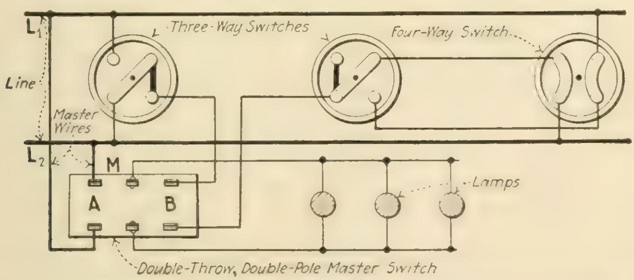


FIG. 328.—Universal master control of one multi-location-controlled lamp group wherein the three- and four-way switches are Carter-connected.

Connections (Sec. 249) as shown in Fig. 328. If the double-throw, double-pole master switch, *M*, is closed to position *A*, the lamps will be lighted regardless of the positions of the three- and four-way switches. If *M* is open, all lamps will be off. If *M* is closed to position *B*, the lighting of the lamps may be controlled by the three- and four-way switches. In Fig.

329, the same principle is extended to include two multi-location-controlled lamp-groups, and two double-pole, double-throw master switches are required. This method is, because of the type and number of master switches required, usually uneconomical.

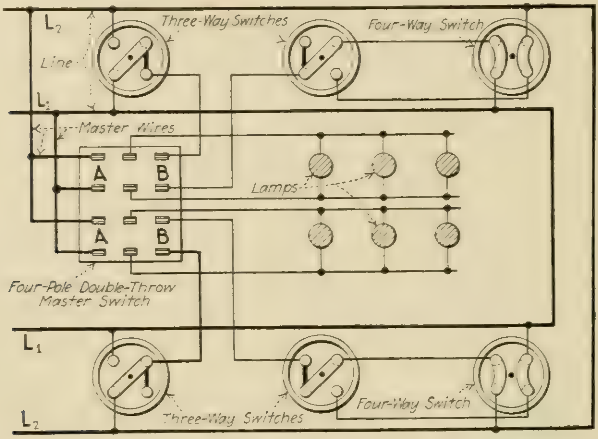


FIG. 329.—Universal master control of two multi-location-controlled lamp groups wherein the three- and four-way switches are connected according to the Carter system.

284. A Combined Carter And Standard System Which Provides A Combined Universal And Straight Master Circuit is shown in Fig. 330. If the master switch, *M*, is closed to position *A*, all lamps will be lighted. If *M* is closed to the right, lamps *C* are controlled by switches, *D*, *E*, and *F*; lamps *K* by switches *N* and *L*; and lamp *G* is controlled by *H*. If *M* is open, lamps *C* are extinguished and can not be lighted by operating switches *D*, *E*, and *F*; and also lamps *K* and *G* are controlled by their respective switches.

285. Control Of A Straight Master Circuit From Two Locations (Fig. 331) may be obtained by the use of two three-way switches, connected as shown, instead of the usual single-pole switch. In fact, such an arrangement may be provided in any master circuit, by using one pair of three-way switches for each switch-pole which is required for single-location control of that master circuit. Except for the use of the two three-

way switches (A and B, Fig. 331) instead of the single-pole switch (M, Fig. 313), the wiring of Fig. 331 is identical with that of Fig. 313.

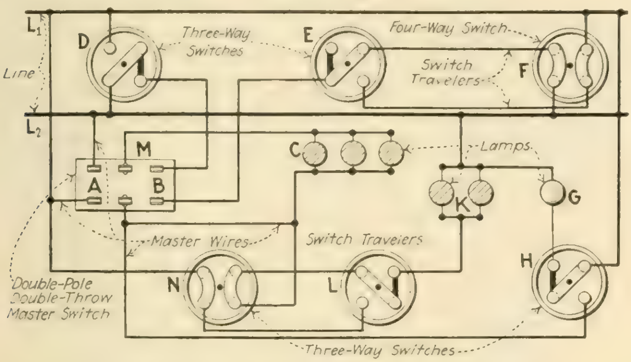


FIG. 330.—Combined Carter and Standard system of three- and four-way-switch connections to provide a combined straight and universal control of the emergency circuit.

NOTE.—TWO-LOCATION CONTROL OF A UNIVERSAL MASTER CIRCUIT may, as suggested above, be obtained by using one pair of three-way switches for each single-pole switch, or one pair of three-way switches for each pole of an n-pole switch which is wired as n single-pole switches. For example, in Fig. 332, two pairs of three-way switches, T_1 and T_2, have

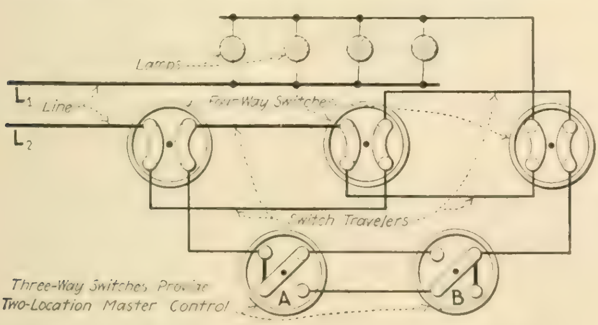


FIG. 331.—Two location control of a straight master circuit.

been substituted for the single-pole master switches, M_1 and M_2, of Fig. 321. Each T_1-switch (Fig. 332) should be mounted in gang with a T_2-switch. Thereby, at either location, a person may open or close one or both of the T_1- and T_2-circuits. The same master control as was explained in Sec. 277, for Fig. 321 is thereby provided. A third master-

control location may be obtained by connecting into the circuit two four-way switches; one between the T_1-switches and one between the T_2-switches.

EXPLANATION.—The two master-control locations (*A* and *B*, Fig. 331 and T_1T_2–T_1T_2 Fig. 332) may be located in different rooms, or one may be located in the owner's bed-room and the other near the front door. If one of the control locations of the universal master circuit (Fig. 332) is located in the owner's bed-room, it may be found convenient to install the other near the front door of the house. Then when all of the occupants leave the house at night, all of the lamps may be extinguished from the front-door location. Or, if only a few lamps are connected to the emergency circuit, these lamps may, to provide burglar protection during their absence, be lighted upon leaving.

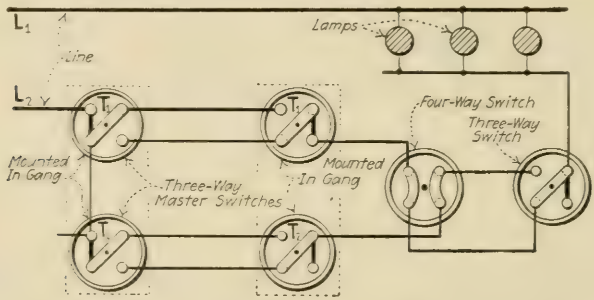


FIG. 332.—Two location control of a universal master circuit.

286. A Master Circuit May Be Provided For A 110–220 Volt, Grounded-neutral, Three-wire System (Fig. 333) by considering each side circuit (Sec. 12) as a separate two-wire circuit. The master circuit for each side circuit may then be connected according to any of the methods previously outlined for a two-wire system. Various master circuits for three-wire systems are described in the following sections.

287. The Master Switch For A Side Circuit Of A Three-wire System may be connected, either: (1) *To the outside wire—hot side*—Figs. 334-*I* and 335. (2) *Or to the neutral wire—dead side*—Fig. 334-*II*. One method is probably as good as the other. However, in any installation, a certain one of the methods should, usually, be followed throughout. This will lessen the possibility of making wrong connections.

288. Various Wiring Diagrams Of Master Circuits For Three-wire Systems are shown in Figs. 333, 336, 337, 338 and 339. The principle involved in all is essentially the same. In

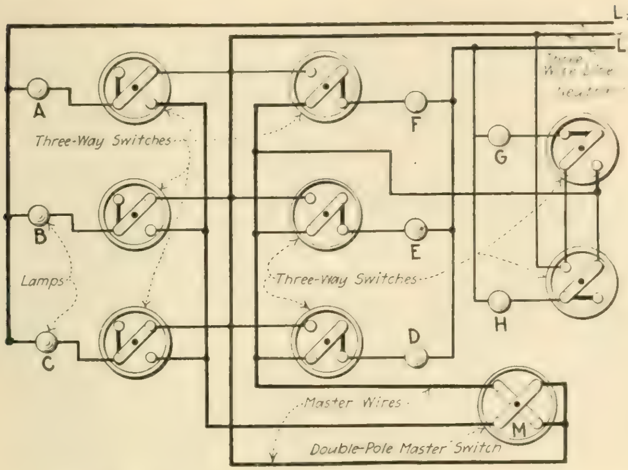


Fig. 333.—Wiring diagram of an emergency circuit for a three-wire installation.

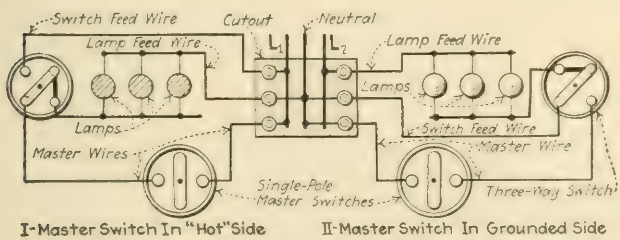


Fig. 334.—Two methods of connecting the master circuit of a three-wire system

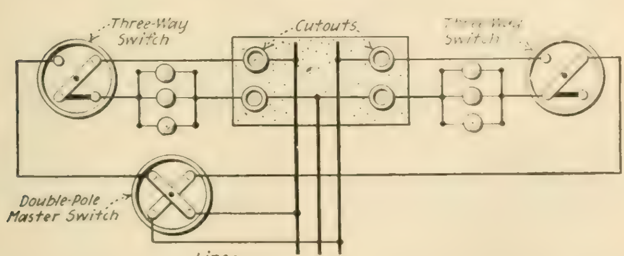


Fig. 335.—Master circuit for a three-wire two-branch installation. (Double-pole master switch in "hot" side.)

Fig. 333, those lamps, *A*, *B*, and *C*, which are connected to one side circuit are not, through the master-circuit wiring, connected to those lamps, *D*, *E*, *F*, *G*, and *H*, which are connected

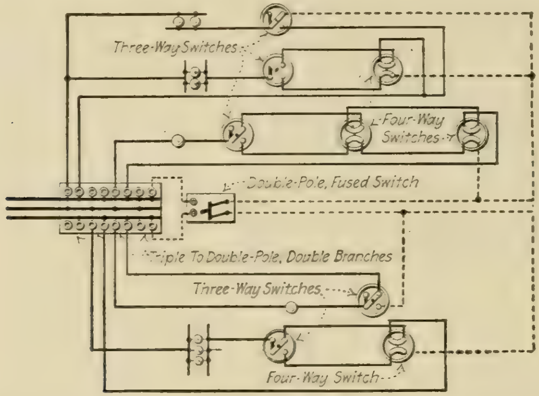


Fig. 336.—Double-pole master switch controlling the emergency circuit of a three-wire, four-branch installation. (Master wires are indicated by dotted lines.)

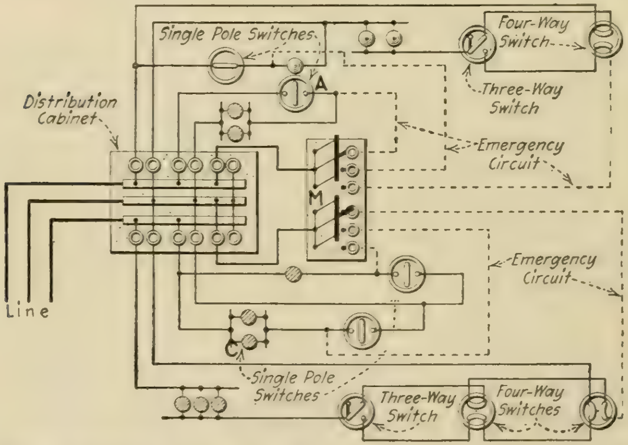


Fig. 337.—Emergency circuit for three-wire, four-branch installation. (Master wires indicated by dotted lines. Since the single-location-controlled lamp groups are each provided with a separate master wire and switch blade, single-pole switches may be used for their control.)

to the other side circuit. In Fig. 336, although the branch circuits which are fed from the same side circuit are interconnected through the master-circuit wiring when the master

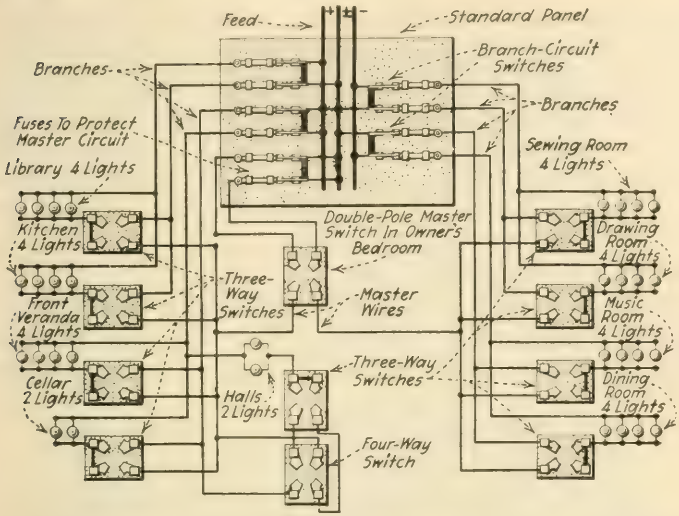


FIG. 338.—Master switch circuit feeding from three-wire panel board, flush switches being used. This arrangement may be used where the master-switch controls as many as 32 sockets. (*Bryant Electric Co.*)

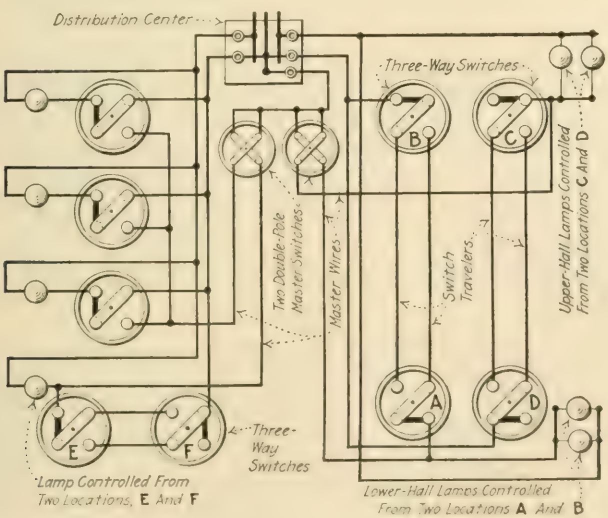


FIG. 339.—Straight master circuit for a three-wire, two-branch installation which contains single- and multi-location-controlled lamp groups.

switch is open, the two side circuits are not so interconnected. In Fig. 337, each branch is provided with a separate master wire and switch blade. And since each branch serves only one lamp-group, single-pole switches may (Sec. 291) be used for the control of each lamp-group which is provided with single-location control. Figure 338 shows an arrangement which is suitable for a four-branch installation wherein the number of sockets served does not exceed 32, and the total wattage does not exceed 1,320.

289. Wiring Diagrams Of Master Circuits Which Will Not Provide Satisfactory Operation For Three-wire Systems are shown in Figs. 340 and 341. The reason that the operation

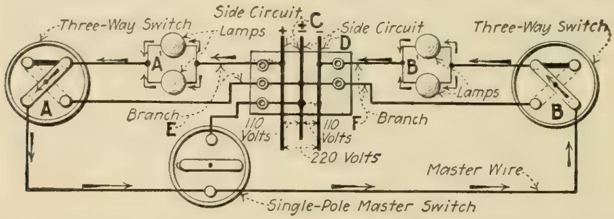


Fig. 340.—Wiring diagram of an incorrect emergency circuit for a three-wire system. (As shown, only one lamp group can be extinguished at a time.)

is unsatisfactory is because the two side circuits are interconnected through the master-circuit wiring when the master switch is open. In Figs. 340 and 341, the emergency circuit wiring is so arranged that the branch circuits, *E* and *F*, which are, respectively, fed from the two side circuits, *C* and *D*, of the three-wire system, are, when the master switch, *M*, is open, interconnected through the master wire, *W*. This, as explained below, makes it impossible to extinguish all of the lamps.

Explanation.—In Fig. 340, if the switch blades of switches *A* and *B* are in the position shown by the dotted lines, lamp-groups *A′* and *B′* will be lighted from their respective side circuits, *C* and *D*. If either switch, *A* or *B*, is then operated so that the blade is in the position shown by the full lines, the corresponding lamp-group, *A′* or *B′*, will be extinguished. If, however, with, say switch *A* in the position indicated by the full lines and lamp-group *A′* extinguished, switch *B* is operated with the intention of extinguishing *B′*, lamp-group *A′* and *B′* will be connected in series-parallel across the outside wires. In the diagram, the outside wires are

marked + and −. Since the outside wires are at a potential difference of 220 volts, the lamps, A' and B' will, if all of them are 110-volt lamps and of the same wattage rating, instead of being extinguished, burn at normal voltage. The current-path is indicated by the arrows. Therefore, only one of the lamp-groups (A' or B', Fig. 340) can be extinguished at any one time. However, if the master switch is closed, all of the lamps will be lighted.

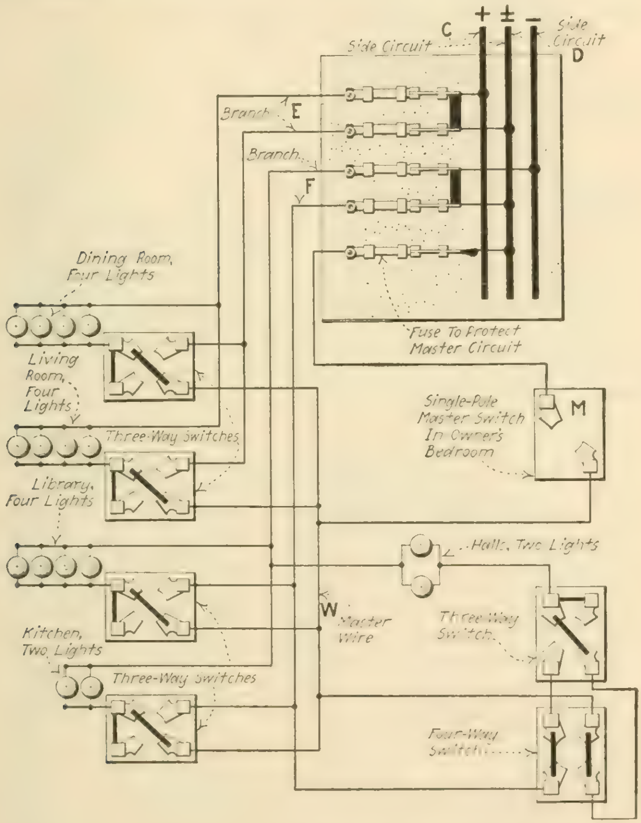


FIG. 341.—Incorrect method of mastering a three-wire, two-branch installation.

290. The Emergency Circuit For A Three-wire System Should Be So Arranged That The Two Side Circuits Will Not Be Interconnected When The Master Switch Is Open. Such errors, which were outlined in Sec. 289 for Figs. 340 and 341, may be corrected by: (1) *Connecting the branches, which are in error interconnected, to the same side circuit*, as suggested in

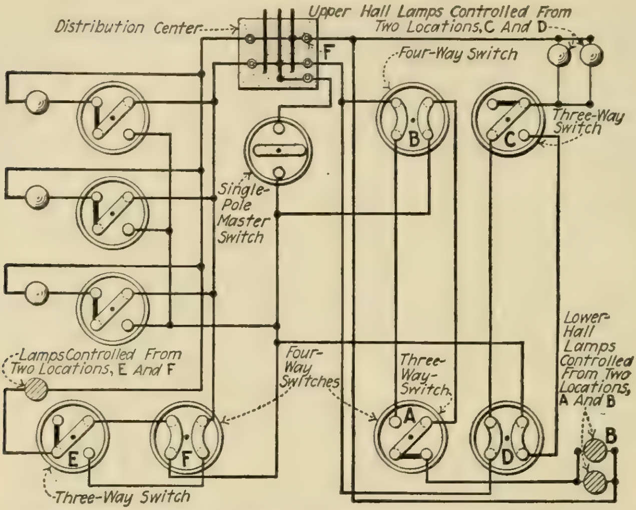


FIG. 342.—Single-pole master switch provides satisfactory control of an emergency circuit for a three-wire two-branch installation when both branches are connected to the same side circuit.

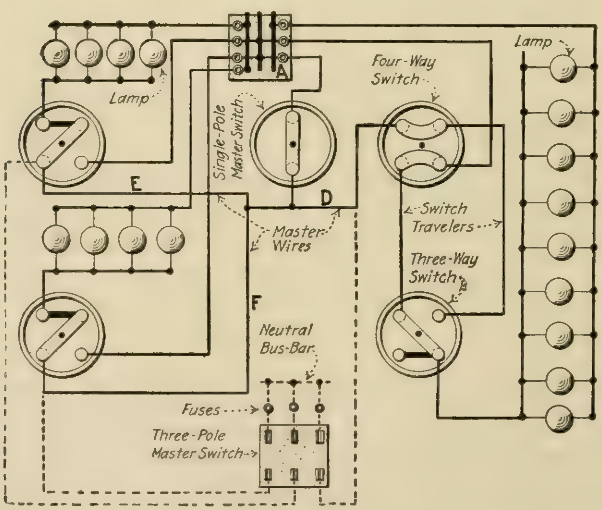


FIG. 343.—Diagram of an incorrect emergency circuit for a three-wire, three-branch installation. (Error may be corrected by removing master wires, *E* and *F* and wiring as shown by dotted lines.)

Fig. 342. (2) *By providing a separate master wire and switch blade for each branch circuit,* as indicated by the dotted lines in Figs. 343 and 344. The method which is suggested in Figs. 343 and 344 will generally be found preferable to that in Fig. 342. This is because that if the remedy is made according to

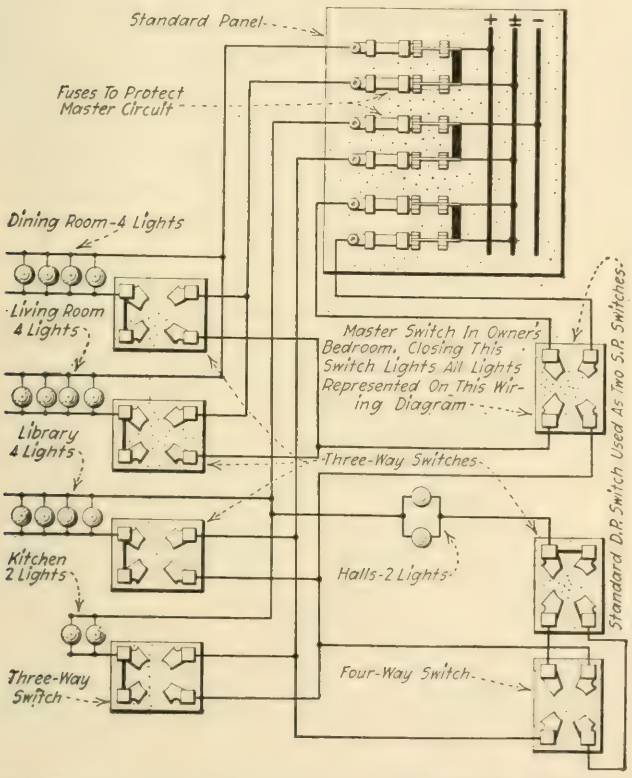


FIG. 344.—Correct method of mastering two branch circuits which are fed from a three-wire grounded-neutral system. (*Bryant Electric Co.*)

Fig. 342, the load is likely to be unbalanced on the side circuits and also the load carried by the master-wire fuse (*F*, Fig. 342) may exceed (Sec. 264) the allowable 660-watt maximum.

291. Except As Mentioned Below, Single-pole Switches Cannot Be Used In Connection With A Master Circuit To Control Individual Lamp-groups. In Fig. 345-*I* the single-pole

switches, S_1 and S_2, are connected to control the two lamp-groups, A and B. Although the master switch, S_3, will, when closed, operate to light all of the lamps, an installation according to this scheme of connections will not operate satisfactorily for the following reason: The master switch, S_3, being open, and S_1 and S_2 closed, both A and B will be lighted. It is now desired to extinguish B, consequently S_2 is opened. However, opening S_2 does not extinguish B, because the current will flow through the circuit as indicated by the arrows. Therefore to extinguish both A and B, switches, S_1, S_2, and S_3, must all be open. A diagram of a satisfactorily-operating installation, wherein three-way switches are used, is shown at *II*.

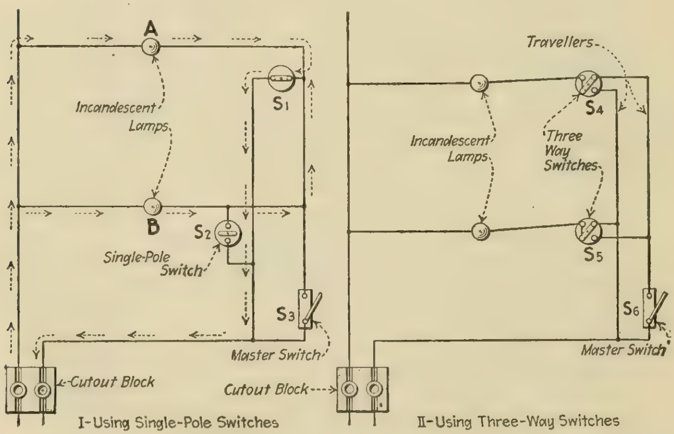


Fig. 345.—Showing single-pole and three-way switches used in a master-switch circuit. (Single-pole switches as shown herein do not provide satisfactory operation.)

Note.—Single-pole Switches For Location-control Of Lamps Which Are In A Master Circuit Will Provide Satisfactory Operation Only Under Certain Conditions. Thus, the operation will be satisfactory only when there is but a single lamp-group connected to a branch, and when the lamp-group on such a branch is served by a master wire which is not, when the master-switch blade is open, connected to any other branch. A schematic diagram of such an arrangement is shown in Fig. 181 and in Fig. 296. A diagram of an actual installation of single-pole-switch lamp-control in connection with a master circuit, which will provide successful operation, is outlined at A, B, and C, Fig. 337. Note that in Fig. 337, A, B, and C, are each provided with a

separate master wire and switch-blade; also that only one lamp-group is connected to a branch (see also Sec. 346).

NOTE.—ONLY ONE LAMP OF A LAMP-GROUP MAY, BY EMPLOYING A SPECIAL SWITCH, BE CONNECTED TO A CIRCUIT as shown in Fig. 346. As shown in *I*, the master switch, *M*, is open, the special switch, *S*, is closed, and all lamps are lighted. In *II*, the special switch, *S*, is open, and, if *M* was open, all lamps would be extinguished. But since *M* is closed, the emergency lamp, *L*, is lighted and lamps, 1, 2 and 3 are extinguished. The use of such a switch may be desirable where the master circuit is often closed throughout long periods of time. Thus, by burning only one lamp on the fixture a much smaller energy-consumption will result than if the entire group was connected to the master circuit

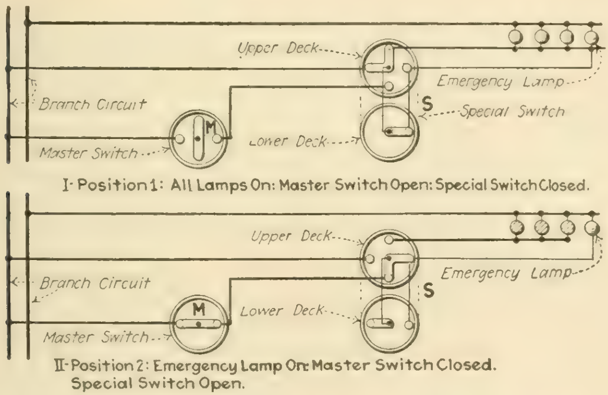


FIG. 346.—Operation of special switch for use in conjunction with master circuits.

by the ordinary method of the three-way switch. Also, if all of the lamps in the group are mounted on one fixture, all of the lamps may be lighted by one switch. This result is ordinarily obtained by the use of two switches (*E*, Fig. 319). If one lamp on the fixture is connected directly to the master circuit as at *L*, Fig. 320, it will, except when the master switch is closed, be unlighted, thus presenting an unsightly appearance (see also Sec. 305).

292. The Procedure To Be Followed In Identifying Conductors And In Testing Out Master Circuits cannot, because of the several wiring-schemes which may be employed, be definitely specified. A complete wiring diagram for any master-circuit wiring job should be made before the actual installation is begun. Then if the wiring diagram is followed,

and each wire is correctly marked when it is installed, no trouble will result. However, if this is not done, the conductors may be identified and the circuit tested out by a judicious application of the principles which were outlined in Div. 5 for three- and four-way-switch circuits.

QUESTIONS ON DIVISION 6

1. Define a *master switch.* Define a *master circuit.*

2. Wherein are master or emergency circuits frequently employed?

3. How may master circuits be classified as regards operating features?

4. How may they be classified according to installation features?

5. What is a *straight*, or *straight-control* master circuit?

6. What is a *universal*, or *universal-control* master circuit?

7. Name the different types of switches which may be used as master switches.

8. What advantage have keyless sockets over key sockets for use on a master circuit?

9. Give the *Code* requirements which must be met in a master-circuit installation.

10. Draw a wiring diagram of, and explain the operation of each of the following for a two-wire system:

a. Straight master circuit for single-location-controlled lamps on one branch circuit.

b. Same as *a*, except lamps connected to three branch circuits.

c. If the load on a master-wire fuse exceeds 660 watts, how may it be corrected?

d. Two branch circuits which have connected to them single and two-location-controlled lamps, wherein the branch circuits are interconnected through the emergency wiring when the master switch is open.

e. A stairway master circuit.

f. Change an ordinary lighting installation to one which is provided with a straight emergency circuit.

g. Usual method of providing a straight-control master circuit.

h. Master control of a two-location-controlled lamp-group by short-circuiting the switch travelers.

i. An emergency circuit for two or more lamp-groups wherein one or more of the lamp-groups are provided with two-location control by two three-way switches. In an installation where the two-location control is obtained by two three-way switches, what must be observed relative to the number of master-switch blades and master wires?

j. Emergency circuit for two branches which serve a combination of one- and two-location-controlled lamps What types of switches will usually provide the more economical installation where a combination of one- and two-location-controlled lamps are connected to the same branch circuit. Illustrate by diagrams.

k. An installation where only a part of the lamps are connected to the same branch circuit.

l. An elementary universal-control master circuit.

m. A universal emergency circuit for combined one- and two-location-control of lamps.

n. Change the diagram of an ordinary wiring installation to one which is provided with a universal master circuit.

o. Universal control of a master circuit for an installation containing multi-location control of lamp-groups by Carter-connected three- and four-way switches.

p. A combined Carter- and standard-connected installation provided with a master circuit.

q. Control of a straight master circuit from two or more locations. Same for a universal master circuit.

11. Wherein may two-location control of a master circuit be applicable?

12. Name two methods of connecting the master switch into the side circuit of a three-wire system. Make a diagram to illustrate each.

14. Explain with a diagram why unsatisfactory operation will result if the emergency circuit for a three-wire system is so arranged that the two side circuits are interconnected through the master wiring when the master switch is open.

15. Draw a diagram to show why single-pole switches cannot be used to control each of two or more lamp-groups on the same branch circuit when a master circuit is provided. Explain.

16. Draw a diagram to show how single-pole switches for the control of a lamp-group may be used in connection with a master circuit. What rules must be followed in such an installation?

17. What should be done before an emergency-wiring installation is begun? Why?

DIVISION 7

ELECTROLIER AND HEATER SWITCH CIRCUITS

293. The Function Of An Electrolier Switch (see Sec. 53 for definition) is to provide varied control of several lamps or groups of lamps which may either be contained in the same fixture or else located at different points. Electrolier switches find their widest application for controlling lamps which are mounted in electrolier or dome fixtures; that is, in fixtures having, say, five lamps, two of which may be used regularly while the remaining three may be cut into the circuit to provide either more light or an added ornamental effect.

NOTE.—THE CONTROL WHICH IS PROVIDED BY AN ELECTROLIER SWITCH may be either: (1) *Restricted.* (2) *Selective.* (3) *Restricted-selective* (see Secs. 15, 16, and 17). The type of control which is provided will depend upon the switch used. Switches which provide each of the above-mentioned controls are described in this division.

294. Electrolier Switches May Be Classified According To The Number Of Circuits Which May Be Controlled, as: (1) *Two-circuit electrolier switches.* (2) *Three-circuit electrolier switches.* Electrolier switches are seldom made for the control of more than three circuits. The circuit-connections for both two- and three-circuit switches are described in following sections.

NOTE.—SINCE PRACTICALLY ALL ELECTROLIER SWITCHES DISCONNECT ONLY ONE SIDE OF THE LINE FROM THE SOURCE OF VOLTAGE, THEY MUST BE CONSIDERED AS SINGLE-POLE SWITCHES insofar as CODE requirements (Secs. 141 to 144) are concerned.

NOTE.—PRACTICALLY ALL ELECTROLIER SNAP-SWITCH CONSTRUCTION employs a mechanism which is of the revolving-blade type (Sec. 23). This mechanism may be operated by any of the following methods: (1) *Rotating-button.* (2) *Push-button.* (3) *Pull-chain.* (4) *Toggle.* See Secs. 29 to 32 for definitions. The principal forms in which electrolier switches are made are: (1) *Surface.* (2) *Flush.* (3) *Pendent.* See Secs. 35 to 37 for definitions.

295. The Conventional Method Of Expressing The Circuit-connections Which Are Provided By An Electrolier Switch is by a series of numbers and words separated by dashes, as "1—2—1 & 2—Off." As explained below, this convention may be used to indicate five different things concerning the switch: (1) *The number of switch-positions.* (2) *The number of circuits controlled.* (3) *The lamp-groups which are lighted at each switch-position.* (4) *The lamp-groups which are extinguished at each switch-position.* (5) *The sequence of lighting and extinguishing the various lamp-groups upon successive switch-handle operations.*

EXPLANATION.—Assume that the control afforded by a certain electrolier switch is expressed by "1—2—1 & 2—Off." Since there are four groups which are separated by dashes, it is a four-position switch. The highest number used in the symbol is 2; therefore, it is a two-circuit switch; that is, two circuits or lamp-groups may be controlled by it. The figure or figures in each group indicate which lamp-group or lamp-groups are lighted for that switch-position. It should also be understood that the figure or figures which do not appear in any group indicate, for that switch-position, that the lamp-group of that number is extinguished. For example, the second group of the above expression contains only the figure "2." That is, for this switch-position, lamp-group No. 2 is lighted, and since figure "1" does not appear in this figure-group, lamp-group No. 1 is extinguished. Also, since the figures "1 & 2" appear in the third group, both lamp-group Nos. 1 and 2 will, when the switch is in this position, be lighted. The word "off" indicates that when the switch is in that position, all lamp-groups are extinguished. The sequence of lighting and extinguishing of the lamp-groups for successive switch-handle operations is indicated by the sequence of the groups of numbers in the symbol. That is, "1—2—1 & 2—Off" indicates that if the switch is in the off-position, the first operation of the switch handle will light lamp-group No. 1; the second operation will light lamp-group No. 2 and extinguish lamp-group No. 1; the third operation will light both lamp-groups; and the fourth operation will extinguish all lamps.

296. A Three-position, Two-point Switch May Be Used As An Electrolier Switch as illustrated in Figs. 347 and 348. Figure 347 is an illustration of an actual installation employing a standard two-point fan-motor switch. The circuits, 1 and 2, are completed by the movable contactor (*B*, Fig. 347) bridging between a circular contact bar, *D*, in the base of the switch, and the stationary contactors, C_1 and C_2. In this illustration, circuit No. 1 is operative; the current path being

from the point where the line, L_2, attaches to the binding-post, P, which is electrically connected to the circular contact bar, D, from D through the movable contactor, B, to the stationary contactor, C_1, thence through the lamp and into the line, L_1.

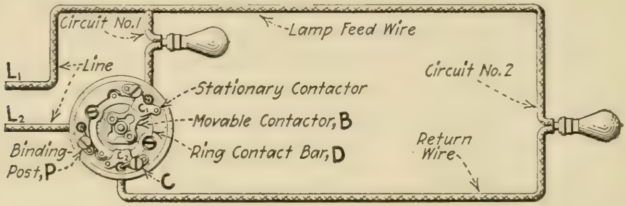


FIG. 347.—A three-position, two-point snap switch connected as an electrolier switch. (The ring contact bar, D, is sometimes called a circular bar.) (*General Electric Company.*)

The circuit-connections for each of the three switch-positions are shown in Fig. 348.

NOTE.—THE CIRCUIT DIAGRAM FOR THE TWO-CIRCUIT, THREE-POSITION ELECTROLIER SWITCH, as shown in Fig. 349, represents the same conditions which existed in the illustration of Fig. 347, with the exception

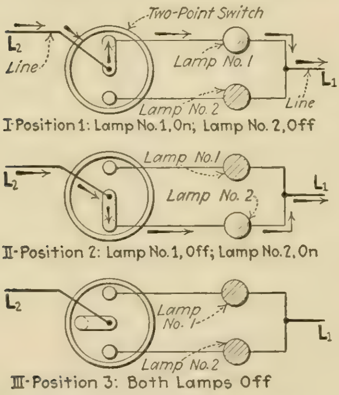


FIG. 348.

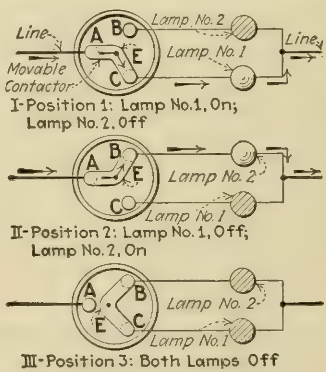


FIG. 349.

FIG. 348.—Circuit diagram of the two-point switch which is shown in the preceding illustration connected as a two-circuit electrolier switch to provide restricted control of two lamps. (Arrows indicate the current-path.)

FIG. 349.—Circuit-connections for a two-circuit three-position electrolier switch providing restricted control of two lamp-groups: "Lamp No. 1" represents one group and "Lamp No. 2" the other group.

that the internal switch-connections which light the lamps are made in a somewhat different manner from that just described for Fig. 347.

As will be noted from the illustrations of *I*, *II* and *III*, (Fig. 349), the electrolier switch there diagrammed has three stationary contactors, or contact points: (1) *Line contact, A*. (2) *Contact B for lamp No. 2*. (3) *Contact C for lamp No.* 1. The movable contactor, *E*, consists of a continuous copper strip forming two arms which are 120 mechanical degrees apart.

It will be evident from the illustration of *I*, that as *E* bridges *A* and *C*, the circuit feeding lamp No. 1 is completed, and the lamp is lighted. At *II*, *E* bridges *A* and *B*. Therefore, lamp No. 2 of the second circuit is lighted. However, at this position of *E*, lamp No. 1 is extinguished. A third turn of the switch-handle throws the movable contactor to the position shown at *III*, so that it bridges *B* and *C*, and consequently, cuts out both lamps Nos. 1 and 2. The restricted control afforded by the switch is termed (Sec. 295) a "1—2—Off" combination. This type of switch finds frequent application in fan-motor circuits which require two speed controls. This switch may also be used (Sec. 311) to control a heating device.

297. A Two-circuit, Three-position, Double-deck Electrolier Switch is diagrammed in Fig. 350. The double-deck arrangement of the movable-contactors is shown in Fig. 351. Each of the movable contactors has two arms which are

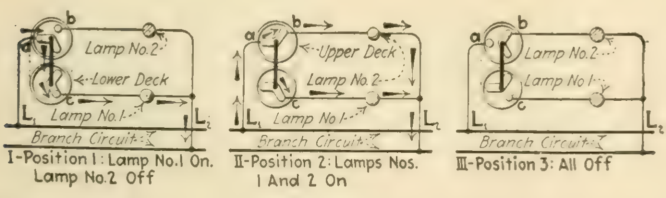


FIG. 350.—Circuits for two-circuit, three-position electrolier switch. (Switch contactors electrically connected.) This switch effects the same connections as does *Bryant* switch No. 2630.

120 deg. apart. The upper- and lower-deck movable contactors are electrically connected. The current path is, for each of the switch-positions (Fig. 350), indicated by arrows. The sequence of the circuit connections is "1—1 & 2—Off."

NOTE.—THE SYMBOLICAL DIAGRAMS WHICH ARE USED HEREIN TO REPRESENT MULTI-DECK SNAP-SWITCHES (Figs. 13-*XX*, and Fig. 350) are intended to obviate a confusion which might result if the upper- and lower-deck movable contactors were shown in a plan view as occupying positions one directly above the other. In the symbols in this book each deck of a multi-deck switch is shown as a complete and separate switch with its respective movable and stationary contactors. When there is

an electrical interconnection between the movable contactors, it is shown by a heavy vertical solid line which is drawn between the centers about which both the upper and lower movable contactors rotate. The dotted lines, which are tangent to the circumferences of the upper and lower decks, indicate that the two movable contactors are carried by the same shaft and mounted on the same switch base. Since the movable contactors of a multi-deck switch are carried by the same shaft, they rotate together, and consequently always occupy the same relative position with respect to each other. In the diagram of each deck, only the stationary and movable contactors of that deck are shown therein. If one binding-post carries two or more stationary contactors so that the stationary contactors in different decks are electrically connected, these two stationary contactors are connected by a heavy line as at A, Figs. 356-*I* and 361-*I*.

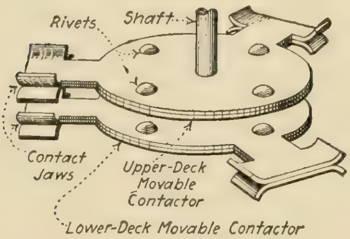


FIG. 351.—Showing an upper and lower-deck arrangement of the movable contactors in a two-circuit three-position electrolier switch.

EXAMPLE.—In Fig. 350-*I*, the line, L_1, connects to the stationary contactor, a, of the upper deck, and the current, as shown by the arrow, flows through the upper-deck movable contactor to the lower-deck movable contactor, thereby bridging stationary contactors a and c. Hence, lamp No. 1 is lighted. If the switch is in the position at *I*, one operation will result in *II*. It will then be noted (Fig. 350-*II*) that stationary contactors a and b, which are in the upper deck, are bridged by the upper-deck movable contactor, thus resulting in lamp No. 2 being lighted. And at the same time, current passes through the upper-deck movable contactor to the lower-deck movable contactor— bridging a and c—thus lighting lamp No. 1. Therefore, when the switch is in the position shown at *II*, both lamps are lighted. The next operation of the switch disconnects the circuit of both lamps Nos. 1 and 2 in a manner which will be evident from a study of *III*. Obviously, the next operation of the switch will return both the upper and the lower movable contactors to the positions which they occupy in *I*.

298. A Two-circuit, Four-position Electrolier Switch of single-deck construction is illustrated in Fig. 352. The contactor-arrangement, and the circuit-connections provided by the four different switch-positions may be understood by reference to Fig. 353. As indicated in Fig. 353, the following combinations are obtainable: (1) *Lamp No.* 1, *on; and lamp No.* 2, *off*. (2) *Lamp No.* 2, *on; and lamp No.* 1, *off*. (3) *Both*

lamps on. (4) *Both lamps off.* Therefore, selective control (Sec. 16) is provided. Such circuit-connection sequence is conventionally expressed as: "1—2—1 & 2—Off." A lighting-and-extinguishing sequence different from that in Fig. 353 may be obtained with the same switch (Fig. 352) by changing

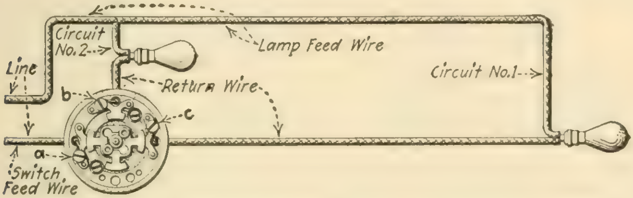


FIG. 352.—Wiring diagram of two-circuit, four-position electrolier snap switch. (Selective control is provided. *General Electric Co.*)

the connection of the switch feed wire from *a*, Figs. 352 and 353-*I*, to *b* Fig. 354, and by changing the connections of the return wires of circuits Nos. 1 and 2 respectively, from *c* and *b*, Fig. 352, to *a* and *c*, Fig. 354. The same control—selective —is provided in Fig. 354 as in Fig. 353. However, the

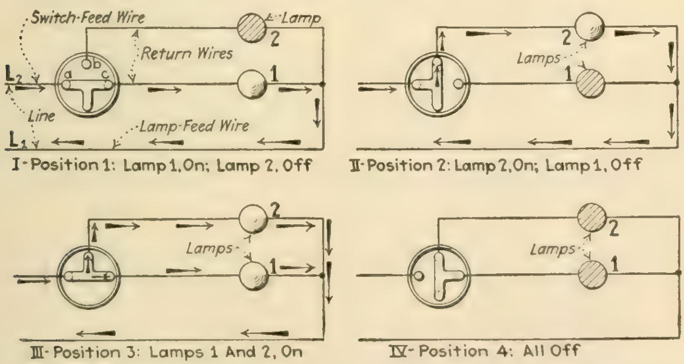


FIG. 353.—Circuit-connections for two-circuit, four-position electrolier snap switch. (Selective control of the following sequence is provided: "1—2—1 & 2—Off.")

sequence of circuit-connections as shown in Fig. 354 is "1—1 & 2—2—Off." The arrows indicate the current-paths.

299. Other Circuit-connections For Two-circuit, Four-position Electrolier Switches are shown in Figs. 355, 356 and 357. The shapes of the upper and lower movable contactors

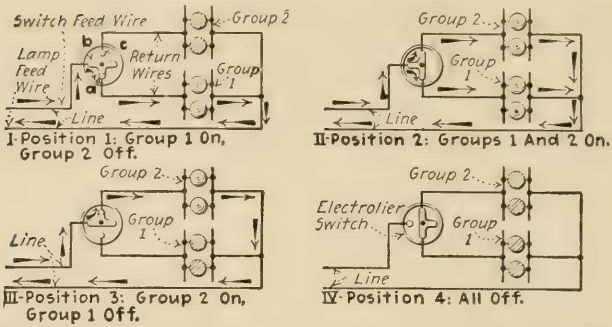


FIG. 354.—Circuit-connections for two-circuit, four-position electrolier switch. (Selective control is provided: "1—1 & 2—2—Off." This switch effects the same connections as does *Bryant* switch No. 2625.)

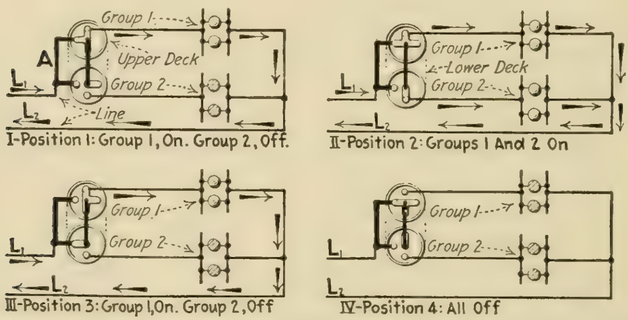


FIG. 355.—Circuit connections for two-circuit, four-position electrolier switch. (Restricted-selective control: "1—1 & 2—1—Off." This switch effects the same connections as does *Bryant* switch No. 2626.)

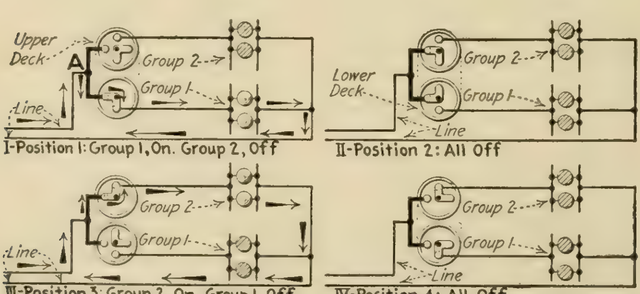


FIG. 356.—Circuit-connections for two-circuit, four-position electrolier switch. (Restricted control, "1—Off—2—Off." This switch effects the same connections as does *Bryant* switch No. 2628.)

of these double-deck switches are indicated in the respective illustrations. The control which is provided by each of these switches when connected as shown, is as follows: Fig. 355, restricted-selective, "1—1 & 2—1—Off;" Fig. 356, restricted, "1—Off—2—Off;" Fig. 357, restricted-selective, "1—Off—1 & 2—Off. The current-paths for each switch-position is indicated by the arrows.

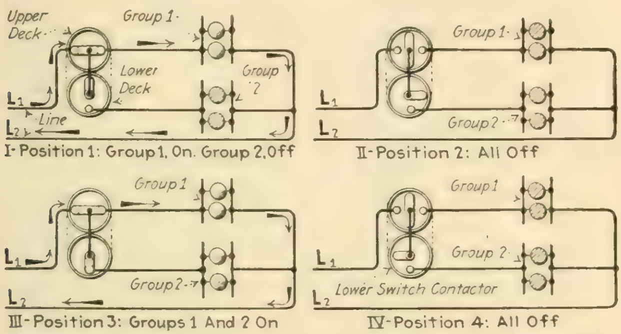


FIG. 357.—Circuit-connections for two-circuit, four-position electrolier switch. Restricted-selective control: "1—Off—1 & 2—Off." (This switch effects the same connections as does *Bryant* switch No. 2629.)

NOTE.—A COMBINATION OF TWO SINGLE-POLE SWITCHES MOUNTED WITHIN THE SAME PORCELAIN CASING AND HAVING A COMMON FEED (Fig. 68) is illustrated in Fig. 358. The movable contactor of each of these single-pole switches (Sec. 90) is actuated by a separate push-button ratchet-gear mechanism (Sec. 89). As will be noted from the diagrams shown in Fig. 358, such a switch can be used for the control of two circuits. At *I*, the lamp, *A*, is connected to the line as indicated by the arrows. If the push button controlling this circuit containing lamp *A* is operated, the lamp will be extinguished. To light the lamps of group *B*, it is necessary to throw the switch controlling the first circuit to the on position and then to throw the switch controlling the second circuit to the on position, as at *II*, Fig. 358. This switch provides a "1—1 & 2—Off" control combination. See also Fig. 102-*XV*, and Sec. 182.

300. A Three-point Fan-motor Switch May Be Used As A Three-circuit Electrolier Switch as illustrated in Figs. 359 and 360. The circuit-connections of such an installation provide (Fig. 360) restricted control of three separate circuits, the sequence of connections being "1—2—3—Off." Therefore, such a switch finds frequent applications for those

installations where it is desired that only one of three lamps may be lighted at one time. The construction of the three-point switch of Fig. 359 is similar to that of Fig. 347, which is described in Sec. 296.

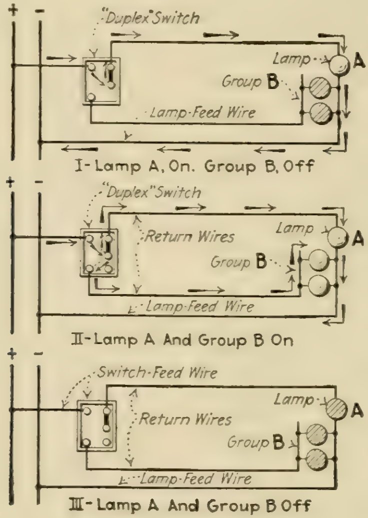


FIG. 358.—Two single-pole switches having a common feed used as two-circuit electrolier switch provide a "1—1 & 2—Off" control.

301. Probably The Most Generally-used Three-circuit Electrolier Switch Is A Four-position, Double-deck Switch which provides a restricted-selective control of the sequence

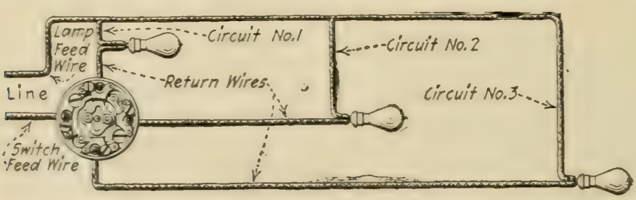


FIG. 359.—Three-point fan-motor switch used as an electrolier switch. (Restricted control of the sequence: "1—2—3—Off," is provided. *General Electric Co.*)

"1—1 & 2—1 & 2 & 3—Off." The circuit-connections are shown in Fig. 361. For wiring diagram of such a switch, see Fig. 102-*XI*. The current-paths for each of the four different switch-positions (Fig. 361) are indicated by the arrows,

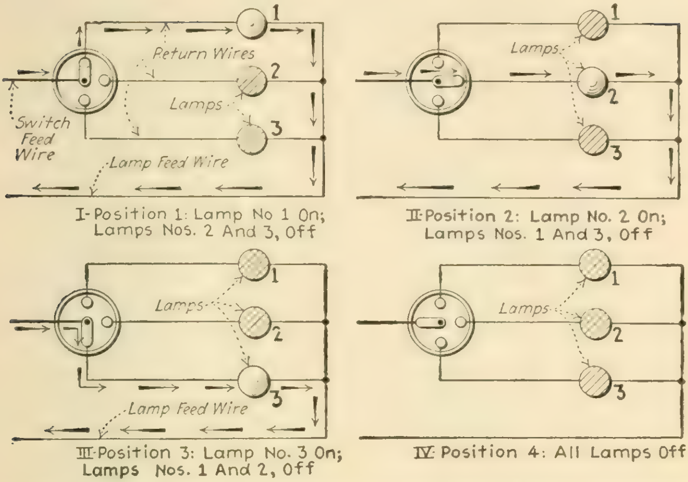


Fig. 360.—Circuit connections of a three-point switch used as a three-circuit electrolier switch to provide restricted control of the sequence: "1—2—3—Off."

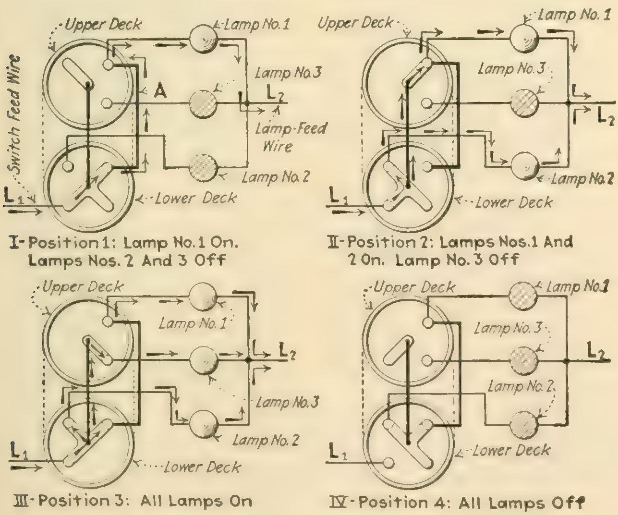


Fig. 361.—Circuit-connections of three-circuit, four-position electrolier switch providing "1—1 & 2—1 & 2 & 3—Off" control. (*List No. 2627, Bryant Electric Co.*)

This switch is made both in the rotating-button, and pull-chain surface forms, and in the push-button flush and pendent forms.

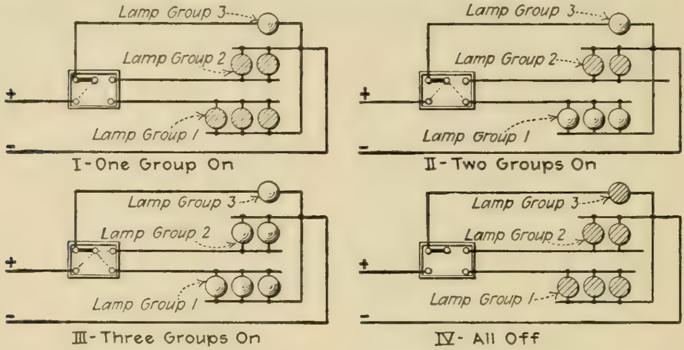


Fig. 362.—Illustrating internal circuits of "Duplex" switch. (*Bryant Electric Co. List No.* 2640.)

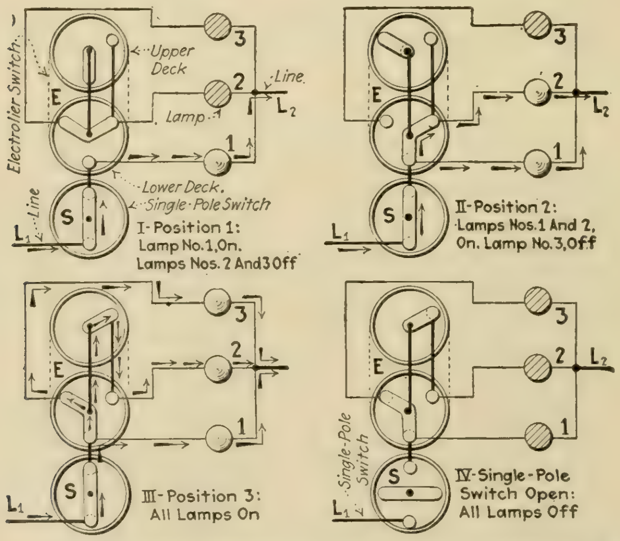


Fig. 363.—Duplex switch consisting of a three-circuit, three-position electrolier switch in series with a single-pole switch. Electrolier switch provides following sequence of control: 1—2 & 2—1 & 2 & 3. (*Bryant Electric Co., List No.* 2640.)

302. A Combination Of A Single-pole Switch With An Electrolier Switch Which Has No Off Position is shown in Fig. 362. As shown in Fig. 363 the single-pole switch is con-

nected in series with the electrolier switch. The three-position, three-circuit electrolier switch, which is of the double-deck type, provides the following control: 1—1 & 2—1 & 2 & 3. Since the single-pole switch is in series with, and may be oper-

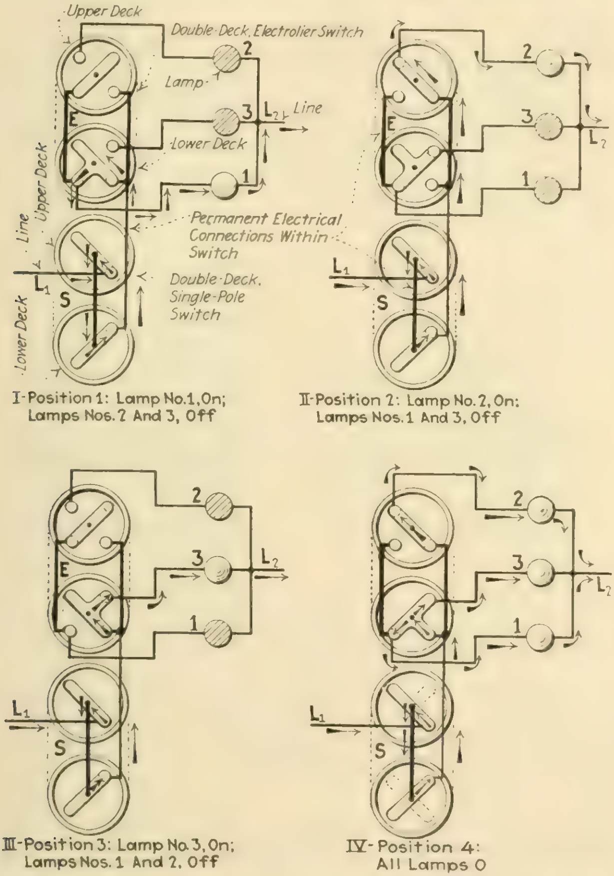


FIG. 364.—Duplex switch consisting of a single-pole switch in series with a three-circuit, four-position electrolier switch which provides the following control: 1—2—3—1 & 2 & 3. (Opening *S*, as indicated by the dotted position in *IV* will at any time extinguish all lamps. *List No.* 2744, *Bryant Electric Co.*)

ated independently of the electrolier switch, all of the lamps may, at any time, be extinguished (Fig. 363-*IV*) by opening the single-pole switch. Thus, in reality, the combination provides

the following control: 1—Off—1 & 2—Off—1 & 2 & 3—Off. The circuit connections for certain other combined single-pole and electrolier switches are shown in Figs. 364 and 365. The arrows indicate current-paths. See also Fig. 102-*XVI* and *XXII*.

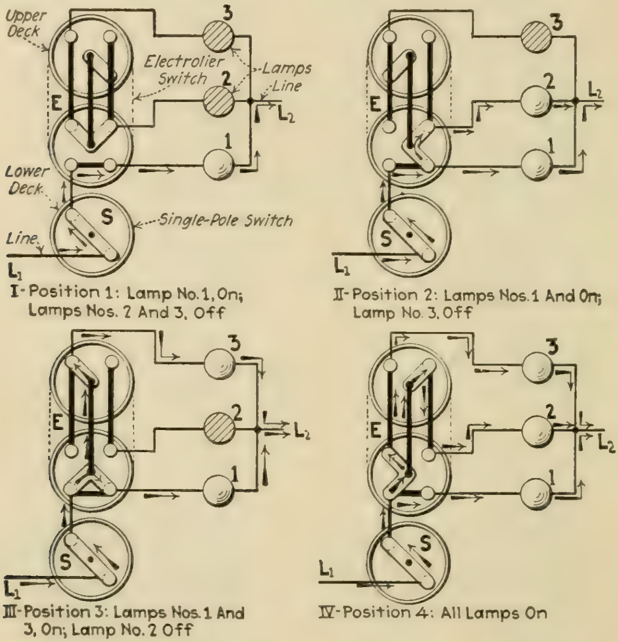


Fig. 365.—Duplex switch consisting of a single-pole switch in series with a three-circuit, four-position electrolier switch which provides the following control: 1—1 & 2—1 & 3—1 & 2 & 3. (With the electrolier switch in any position, opening the single-pole switch will extinguish all lamps. *Bryant Electric Co., List No.* 2745.)

303. A Three-circuit Electrolier Switch Wired In Conjunction With Two Three-way Switches And One Four-way Switch is illustrated in Fig. 366. An actual installation which employs the same circuit connections is shown in Fig. 367. The three-way switches, T_1 and T_2, together with the four-way switch F, provide three-location control for lamp A, and if the electrolier switch, E, is in either of the closed positions, three-location control is also provided for the electrolier lamps. Since the electrolier switch, E, is connected into the circuit

ahead of T_1, T_2, and F, none of the electrolier lamps can be lighted without also lighting A. Also, if E is in the off posi-

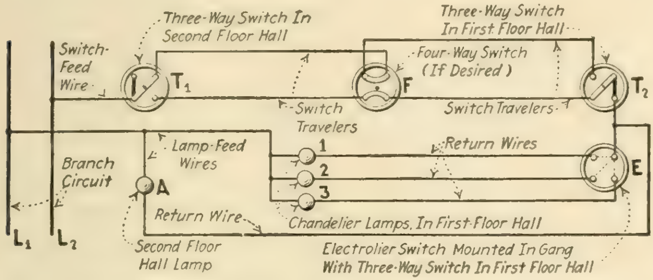


FIG. 366.—Electrolier switch wired in conjunction with three- and four-way switches. With switches in positions shown all lamps are off.

tion, none of the chandelier lamps can be lighted by operating T_1, T_2, or F. Therefore, with such an installation, if three-location control of the up-stairs and down-stairs hall lamps is

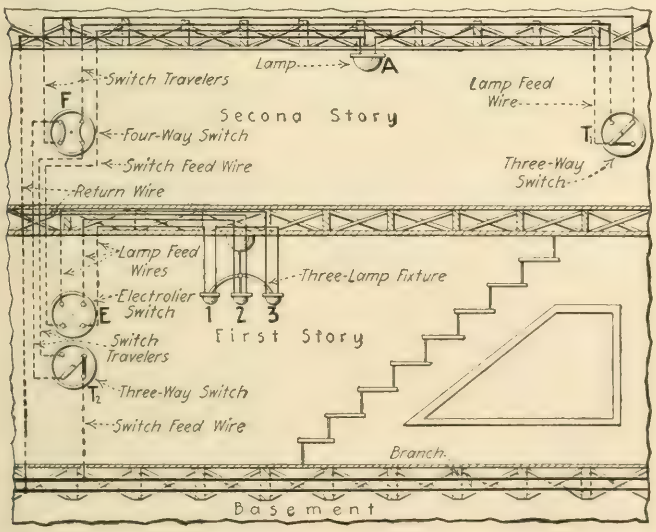


FIG. 367.—Illustrating an actual installation of electrolier switch wired in conjunction with three- and four-way switches.

desired, the electrolier switch, E, must always be left in one of the closed positions.

304. A Method Of Obtaining Multi-location Control Of Lamps Which Are In Turn Controlled By An Electrolier Switch is illustrated in Fig. 368. The electrolier switch, E, which has no off position, is mounted in gang with the three-way switch T_1. This combination provides one control location. The three-way switch, T_2, provides another control location. Additional control locations may be obtained by connecting four-way switches into the switch travelers as suggested in Fig. 253.

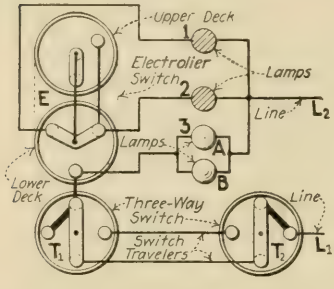


Fig. 368.—Two-location control of lamps which are in turn controlled by an electrolier switch which has no *off* position.

Explanation.—The electrolier switch, E, Fig. 368 is identical with the electrolier switch, E, Fig. 363. Thus, the control sequence provided by E (Fig. 368) is: 1—1 & 2—1 & 2 & 3. Hence if a person is at the ET_1-location, he may by means of E, select either of the three available lamp-group combinations (Fig. 363-*I*, *II*, or *III*), and then light the combination which was selected by T_1. Since in this particular switch (E, Fig. 368), lamp-group No. 1 is (Fig. 363) always connected into the circuit, it may be desirable to install two lamps (A and B, Fig. 368) in this group. Then by locating a three-lamp fixture—consisting of lamps 2, 3, and A of group 1—and switches E and T_1 in the lower hallway, and lamp B and switch T_2 in the upper hallway, both hallways can then be lighted from either the up-stairs or down-stairs switch location.

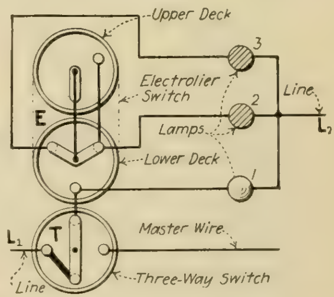


Fig. 369.—An electrolier switch which has no *off* position connected in series with a three-way switch for use in conjunction with an emergency circuit. (With the master switch closed, one or other of the combinations, as outlined in Fig. 361 will always be lighted. With the master switch open, any combination may be extinguished by T.)

305. One Or More Lamps Of An Electrolier-switch-controlled Multi-lamp Fixture May Be Connected To An Emergency Circuit (Div. 6) by one of the following methods: (1) *By directly connecting the lamp to the master wire*, as at L, Fig. 320. (2) *By connecting one or more lamps of the fixture to a*

separate three-way switch, Fig. 319. (3) *By connecting a three-way switch in series with a "no off-position" electrolier switch,* which might be made as shown in Fig. 369. (4) *By the use of a special switch,* as explained below. Connecting a lamp directly to the master circuit may, since the lamp will only be lighted when the master switch is closed, be objectionable from the standpoint of appearance. Although the methods which are outlined above in (2) and (3) eliminate any objection as to appearance, the use of the additional three-way switch may add materially to the installation cost.

EXPLANATION.—A SPECIAL ELECTROLIER SWITCH, *E*, FOR USE WITH A MASTER CIRCUIT, might be arranged as shown in Fig. 370; this is a double-deck switch, the upper deck of which is identical to that of the

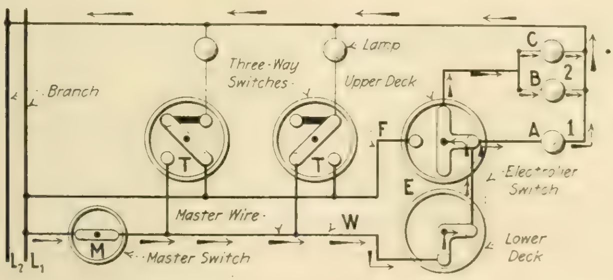


FIG. 370.—Special electrolier switch for use with an emergency circuit.

single-deck switch of Fig. 353. Therefore, the control provided is: 1—2—1 & 2—Off. But when the switch (*E*, Fig. 370) is in the off position, the movable contactor of the lower deck then connects the three lamps, *A*, *B*, and *C*, to the master wire, *W*, of the master circuit. Also this is the only position wherein *A*, *B* or *C* will be connected to *W*. Therefore, if the master switch, *M*, is closed when the upper-deck movable contactor is in the open position, *A*, *B* and *C* will then be lighted, the current path being as indicated by the arrows. With any other position of *E*, the lamps will be lighted through *F* as indicated in Fig. 353.

306. The Term "Heater Switch" is usually applied to those snap switches which are so designed that by successive operations of the switch handle, two elements—coils or resistors—of a heating device may, in addition to disconnecting the elements from the supply circuit, do one or more of the following: (1) *Connect only one coil to the supply circuit.* (2) *Connect the*

two coils in parallel to the supply circuit. (3) *Connect the two coils in series to the supply circuit.* Although a switch of any type, such as an ordinary single-pole switch, a double-pole switch, a three-way switch, or the like, may be used for the control of heating devices, they are not, even when so used, generally termed heater switches.

Note.—The Single- And Double-pole Switch Circuits Which Were Described As Dimmer Circuits (Div. 4) may be used as heater switches by substituting a resistor or heating element for each lamp-group.

Note.—Any Switch May Be Used As A Heater Switch If Its Approved Capacity Is Not Exceeded. The ratings of those snap switches which are, in the trade, called heater switches, vary from 10 amp. at 125 volts (1,250 watts) up to 35 amp. at 250 volts (8,750 watts).

307. The General Requirements Which Are Necessary For The Successful Operation Of Heater Snap Switches are: (1) *Sufficient current-carrying capacity.* (2) *Sufficient movable contactor speed to prevent a dangerous arc upon make and break.* (3) *Ability to withstand a high temperature.* The problems of current-carrying capacity and of make-and-break action cannot be determined by sight or theory. The switch either operates successfully or it does not. However, all *approved* (Sec. 115) heater switches are tested, and will usually operate satisfactorily if their rated load is not exceeded. Sometimes the switches on electric ranges and other heating devices are mounted too close to the heating elements, or sufficient heat-insulation from the heating elements is not provided. Under such conditions, switch failure may be due to the heat which is transmitted from the heating elements.

308. Heater Switches Must Be Of A Type Which Will Plainly Indicate Whether The Device Controlled Is "On" Or "Off" (Sec. 150).—In heater switches of the surface type (Fig. 371), this indication is usually provided by the words "Off," "High," "Medium" and "Low" (see explanation below), arranged as suggested in Sec. 114. When a plug connection (Sec. 150) is used for a heater circuit, the indication may be provided by a combination receptacle—pilot lamp and switch—(Fig. 372) which is so wired that when the switch is closed, the pilot lamp will be lighted.

Explanation.—The Words "Off," "High," "Medium," And "Low" As Applied To Heater-switch Indications merely indicate the comparative amount of heat which will be emitted by the heating device when the switch is in the respective positions. That is, if a

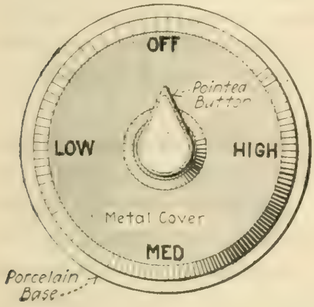


Fig. 371.

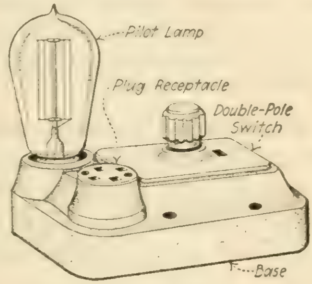


Fig. 372.

Fig. 371.—Surface type heater switch showing method of indicating whether the current is off or on. (The current is on when the pointed-button points to "High," "Low," or "Med." *Bryant Electric Co., List No.* 2801.)

Fig. 372.—Ready-wired surface-type heater-control combination receptacle, switch, and indicating lamp. (The pilot lamp is wired in parallel with the receptacle so that the lamp is lighted when the switch is closed. *Bryant Electric Co., List No.* 466.)

heater switch (Fig. 373), the operating sequence of which is *off*, *high*, *medium* and *low*, controls two equal-capacity heating elements, *A* and *B*, of a heating device, no current will flow when the switch is in the off

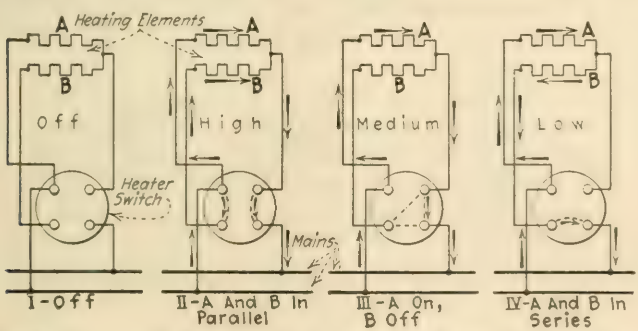


Fig. 373.—Illustrating the meaning of heater-switch indications. (Dotted lines indicate the connection which are made inside of the switch. Arrows indicate current paths. (*Bryant Electric Co., List No.* 2619.)

position. When the switch indicates "high" (Fig. 373-*II*), *A* and *B* are in parallel. When the switch indicates "medium" (Fig. 373-*III*), only one element, as *A*, is on, and the other element is off. When "low" is indicated (*IV*), the two elements are in series.

Consider two heating elements, which are alike in every respect and in which there is no change in resistance with a temperature change. Now assume that the two elements will, when connected in series to a given source of voltage (Fig. 373-*IV*) give off one heat unit. Then, one of the elements, when connected to the same source (*III*), will give off two heat units. And if the two elements are connected in parallel (Fig. 373-*II*) to the same source of voltage, four heat units will be emitted. If the two elements are unlike in shape or are of unequal resistances the above proportions do not hold.

309. Heater Switches Are For Use On Heating Devices Which Have Two Heating Elements—coils or resistors—in each unit such as cooking devices, radiators, mangles, industrial heaters for glue-pots, linotype metal, and the like. As suggested in Sec. 306, ordinary single-pole or double-pole switches, such as those which are generally used for lighting-circuits, may be used to control heating devices which have only one heating element in each unit. Hence, such switches may be used for flat irons, toasters, curling irons, water heaters and the like. Various types of heater switches and the circuit-connections which are effected thereby are treated in the following sections. For methods of installations, see the author's WIRING FOR LIGHT AND POWER.

310. Heater Switches May Be Classified According To The Circuit-connections which are made as: (1) *A series switch*, Fig. 374, whereby the two heating elements may, by successive

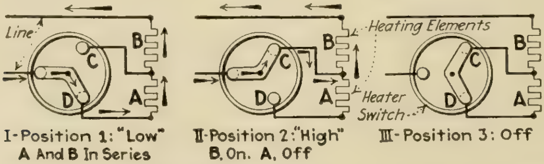


FIG. 374.—Single-pole series heater switch providing the following sequence of connections: "Low—High—Off."

operations of the switch handle, first be connected across the line in series, then only one element connected across the line, then both elements disconnected from the line. (2) *A parallel switch*, Fig. 376, whereby the two heating elements may, by successive operations of the switch handle, first be connected across the line in parallel, then only one element connected

across the line, then neither element connected to the line. (3) *A series-parallel switch*, Fig. 382, whereby the two heating elements may, by successive operations of the switch handle, first be connected across the line in parallel, then across the line in series, then only one connected across the line, then neither connected to the line. The series and parallel heater switches are usually of the single-pole type, whereas the series-parallel switches are regularly manufactured in both the single- and double-pole types. Circuit connections of switches of each of the above classifications are described in the following sections.

311. The Circuit-connections For A Single-pole Series Heater Switch are diagrammed in Fig. 374. As indicated, it is a three-position, single-deck switch. When connected to control two heating elements, as shown in Fig. 374, the

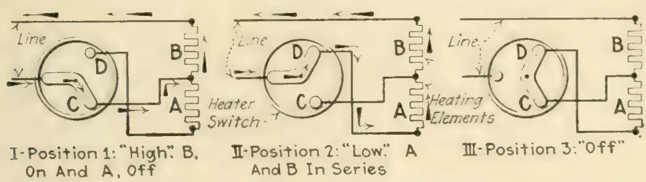


Fig. 375.—Single-pole series heater switch which provides the following sequence of connections: "High—Low—Off."

sequence of operation is: "Low—High—Off." By interchanging the connections *C* and *D* of Fig. 374, the sequence of operation (Fig. 375) will be: "High—Low—Off." The circuit-connections which are provided by a heater switch such as that shown in Figs. 374 and 375 are the same as those which are provided by the electrolier switch in Fig. 349. Such a switch, if of suitable capacity, may be used either to control a heater unit or to control two lamp-groups.

Note—The Kind Of Apparatus Which A Switch Controls Sometimes Governs The Name Which Is Applied To The Switch. If a switch such as that described above is used to control lamps, it is usually called an electrolier switch. And the same switch, if used to control a heating device, is then ordinarily called a heater switch.

312. The Circuit-connections For A Single-pole, Parallel Heater Switch are shown in Fig. 376. It is a single-deck, four-

position switch. When connected as shown in Fig. 376 to control two heating elements, *A* and *B*, of unequal capacity, successive operations of the switch so connect the heating elements to provide the following sequence: "Low—Medium

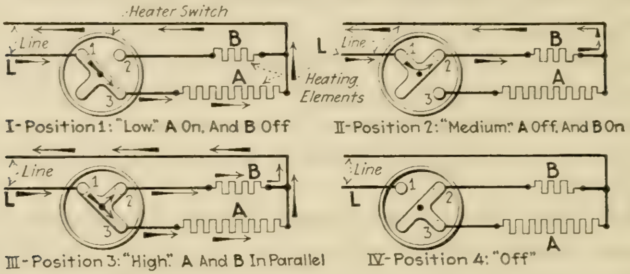


Fig. 376.—Single-pole parallel heater switch controlling a unit consisting of two heating elements of unequal capacity. (As connected the following sequence of heating effects are provided: "Low—Medium—High—Off." (*Bryant Electric Co., List No.* 2216, 10 *amp. at* 125 *volts* or 5 *amp.* at 250 *volts;* that is 1250 watts.)

—High—Off." If *A* and *B* are of equal capacity, only two heating effects—"High" and "Low"—will be provided (see explanation below). This switch is identical to that shown in Fig. 353, and (Sec. 298) may be used either as a heater

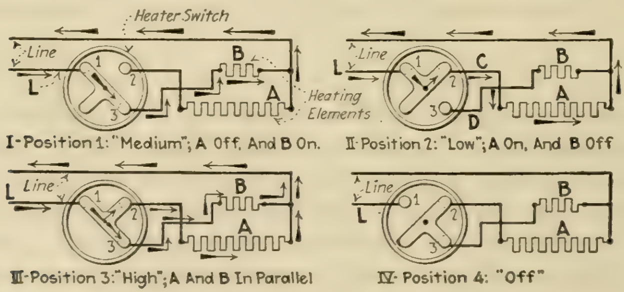


Fig. 377.—Single-pole parallel heater switch controlling two elements of unequal capacity. As connected the following sequence of heating effects is provided: "Medium—Low—High—Off."

switch or as an electrolier switch. If the connections of the line, *L*, and the heating elements, *B* and *A*, are changed from binding-posts 1, 2, and 3, as shown in Fig. 376, to 1, 3, and 2, as shown in Fig. 377, the operating sequence will then be: "Medium—Low—High—Off." The other possible changes

which may be made in the external connections, and the operating sequence which results therefrom are shown in Figs. 378, 379, 380 and 381.

EXPLANATION.—Since element *B* (Fig. 376) has a lower resistance than *A*, more current will flow (Fig. 376-*II*) through *B* than will flow through *A* (Fig. 376-*I*). In *III*, the two elements are in parallel. This

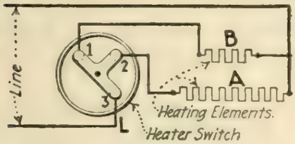


FIG. 378.—Single-pole parallel heater switch, controlling two heating elements of unequal capacity, which is connected to operate "High—Low—Medium—Off."

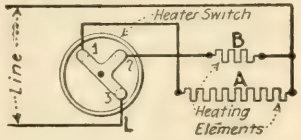


FIG. 379.—Single-pole, parallel heater switch controlling two heating elements of unequal capacities. (The switch, as connected operates: "High—Medium—Low—Off."

still further decreases the resistance of the unit, thereby developing more heat than in either *I* or *II*. Hence, by using such a switch with a unit which consists of two unequal-capacity elements, three different "heats" are provided. If the elements were of the same capacity, the amount of heat given off by *I* would be equal to that given off by *II*, then only two "heats" would be available.

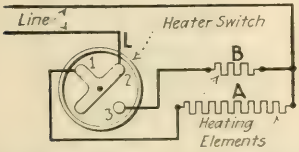


FIG. 380.—Single-pole, parallel heater switch controlling two heating elements of unequal capacities. (When connected as shown, the switch operates: "Low—High—Medium—Off."

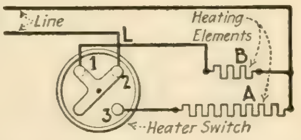


FIG. 381.—Single-pole, parallel heater switch controlling two heating elements of unequal capacities. (As connected, the switch operates: "Medium—High—Low—Off.")

NOTE.—THE BINDING-POSTS, OR TERMINALS, OF PRACTICALLY ALL SNAP SWITCHES ARE MARKED TO INDICATE HOW THE SWITCH SHOULD BE CONNECTED. This marking, which is usually stamped on the porcelain, corresponds to the marking on the diagram of connections (Figs. 101, 102, 103 and 104), which will be furnished by the manufacturer of the switch. If the markings on the switch have been defaced, or if the diagram of connections is not available, the wireman should, if possible before connecting up the switch, carefully trace out the internal connections for each switch position. Otherwise, trouble is likely to result. Also, if the connections to a heater switch are, for the purpose

of changing the operating sequence, changed from that which is indicated on the porcelain, the wireman should, by carefully tracing out the internal switch connections for each switch position, first determine whether or not the switch will operate under the changed connections. If it will operate successfully with the connections changed, the indicator should then be altered to correspond with the new operating sequence.

313. The Circuit-connections For A Single-pole, Series-parallel Heater Switch are diagrammed in Fig. 382. This four-position switch, when connected to control a heating device which has two equal-capacity heating elements, oper-

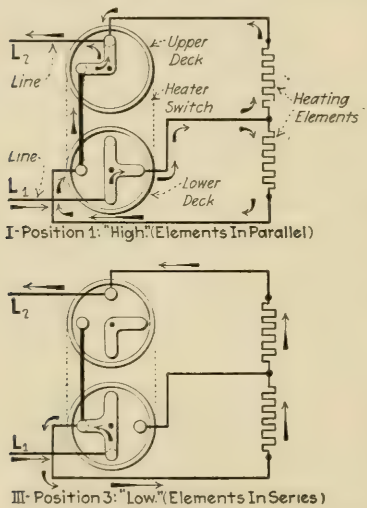


FIG. 382.—Circuit-connections of a single-pole series-parallel heater switch controlling two heating elements of equal capacity which operates: "High—Medium—Low—Off." (*Bryant Electric Co., List No.* 2619.)

ates: "High—Medium—Low—Off." See Fig. 104-*XIV* for wiring diagram. The switch which is diagrammed in Fig. 383 is similar to that in Fig. 382. However, the movable-and-stationary-contactor arrangement of Fig. 383 control the heating elements to operate: "Low—Medium—High—Off."

314. The Circuit-connections For A Double-pole, Double-deck, Four-position, Series-parallel Heater Switch are shown in Fig. 384. This switch, when connected as shown to control a heating device which has two equal-capacity heating elements, operates: "High—Low—Medium—Off." When in

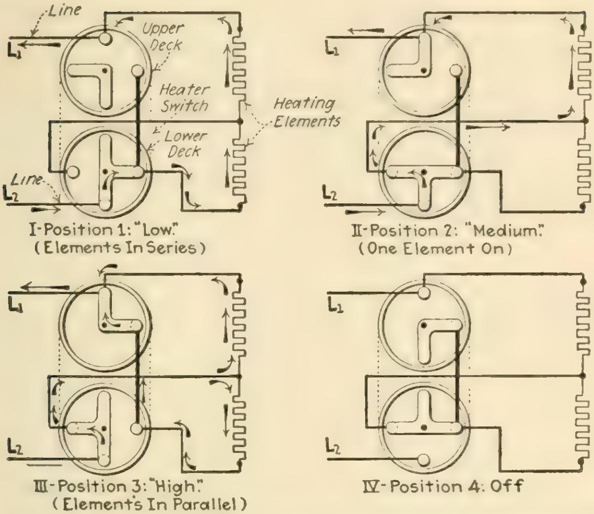


FIG. 383.—Circuit-connections of a single-pole, series-parallel heater switch controlling two heating elements of equal capacity. (The switch operates "Low—Medium—High—Off.")

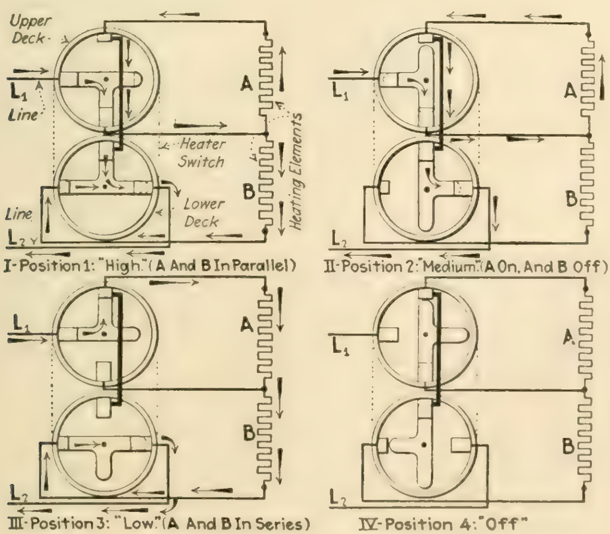


FIG. 384.—Circuit-connections of a double-pole, series-parallel heater switch controlling two equal-capacity heating elements, A and B, which operates "High—Medium—low—Off." (*Bryant Electric Co., List No.* 2800.)

the off position (Fig. 384-*IV*), all wires of the heating elements are disconnected from the line. It is therefore a double-pole switch and may be used on devices which have a capacity (Sec. 150) above that required for single-pole heater switches. This switch is *approved* for 30 amp. at 125 volts, or 15 amp. at 250 volts, that is, for 3,750 watts. See Fig. 104-*XIII* for wiring diagram.

QUESTIONS ON DIVISION 7

1. What is the function of an electrolier switch?

2. What applications are made of electrolier switches?

3. Name and define the three types of controls which may be obtained with electrolier switches.

4. Classify electrolier switches according to the number of circuits controlled.

5. What is the maximum number of circuits for which electrolier switches, as generally manufactured, will control?

6. Why are electrolier switches considered as single-pole switches insofar as Code requirements are concerned?

7. In general, what are the methods of operation and the forms of electrolier switches?

8. What is the conventional method of expressing the circuit-connections which are provided by an electrolier switch?

9. What is meant by the expression, "1—2—1 & 2 & 3—Off," as applied to electrolier switches?

10. Give five facts about the switch which such an expression indicates.

11. Show by sketch how a three-position, two-point, fan-motor switch may be used as an electrolier switch. Make a circuit diagram for each of the three positions.

12. Make a sketch of the circuit-connections of a two-circuit, three-position electrolier switch for each of the three positions.

13. Make sketches of the circuit-connections of three different two-circuit electrolier switches; one to provide selective control; one to provide restricted control; and one to provide restricted-selective control.

14. Make a sketch to show how two single-pole switches having a common feed may be used as an electrolier switch.

15. Show by sketch how a three-point, fan-motor switch may be used as a three circuit electrolier switch.

16. Make a sketch of the circuit-connections for each position of a three-circuit, four-position electrolier switch.

17. Show by sketch how multi-location control of lamps which are in turn controlled by an electrolier switch may be obtained.

18. Name and explain by diagram four methods in which an electrolier-switch-controlled lamp-group may be connected to a master circuit. What are the advantages and disadvantages of each method?

19. What is a heater switch?

20. How may a single- or a double-pole switch be used as a heater switch. Explain by sketch.

21. Give the capacity range within which heater switches of the snap type are generally manufactured.

22. What are the requirements for the successful operation of heater snap-switches?

23. Why should a heater switch be protected from the heat of the heating device which it controls?

24. How may a heater switch be made indicating?

25. How may a heater outlet be made indicating?

26. Explain the meaning of the terms, "High," "Low," "Medium," and "Off,' as used on indicating heater switches.

27. What are the relative amounts of heat which will be emitted by two similar heating elements when connected in series across the line, when only one element is across the line, and when the two elements are in parallel across the line? Does this relation hold if the two elements are dissimilar?

28. Where are heater switches frequently used?

29. Classify heater switches according to the circuit-connections which may be effected by them.

30. What is meant by the terms: (*a*) *Series switch.* (*b*) *Parallel switch.* (*c*) *Series-parallel switch?* Make a sketch of each.

31. Make a sketch of the circuit-connections for: (*a*) *A single-pole, series heater switch.* (*b*) *A single-pole, parallel heater switch.* (*c*) *A single-pole, series-parallel heater switch.* (*d*) *A double-pole, series-parallel heater switch.*

32. What may sometimes govern the name which is applied to a switch? Give an example.

33. Show by sketch how the control-sequence of a heater switch may be changed by merely changing the wires from one binding-post to another.

34. How are the terminals of all snap-switches generally marked.

35. What should always be done before connecting up a snap switch?

DIVISION 8

REMOTE-CONTROLLED, DOOR, AND TIME SWITCH CIRCUITS

315. A Remote-controlled Switch is a switch which may be operated electrically from a distance by closing or opening a control circuit (Sec. 316) which extends through one or more electromagnets. The electromagnets form a part of and are mounted on the switch. A remote-controlled switch is sometimes called a *remote control switch* or a *remote switch;* also a *magnet switch.*

EXAMPLE.—A DIAGRAM TO ILLUSTRATE THE DEFINITION OF A REMOTE-CONTROLLED SWITCH is shown in Fig. 385. At *I*, the remote-controlled switch, *R*, is open. By closing the single-pole switch, *S*, current flows through the electromagnet, *M*, as indicated by the light

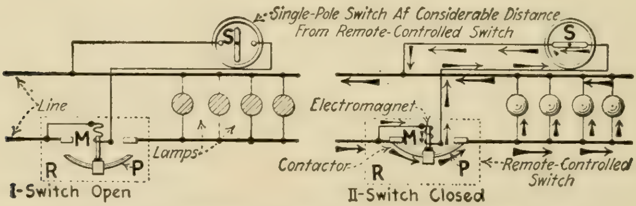


FIG. 385.—Illustrating definition of remote-controlled switch.

arrows in *II*. This current energizes *M*, thereby pulling the contactor, *P*, upward to the closed position. Current may then flow through the lamp circuit, as indicated by the heavy arrows, thus lighting the lamps. As long as *S* is closed, *M* remains energized, and *P* is held in the closed position. If *S* is opened, the electromagnetic force on *P* is removed, and *P* falls by gravity. Thus, *R* is opened and the lamps are extinguished.

NOTE.—THEORETICALLY, A REMOTE-CONTROLLED SWITCH MAY BE REMOTELY CONTROLLED EITHER MECHANICALLY OR ELECTRICALLY. Switches which are used for the control of high-voltage circuits are frequently provided with a system of links and levers so that the switch may be manually operated by a handle which may be located several or many feet away from the switch mechanism. Such a switch is truly a

remote-controlled switch, in the sense that it may be operated from a location which is remote from the switch. However, in this book most of the remote controlled switches which will be considered are electrically remote controlled. Hence, herein, unless otherwise specified the term "remote-controlled switch" will ordinarily mean an electrically remote-controlled switch.

316. Remote-controlled Switches Have Two Separate Circuits: (1) *The control, or operating circuit*, Sec. 328. (2) *The load circuit which is the circuit which serves the electrical load and which is controlled by the opening and closing of the remote-controlled switch.* Each of these circuits are treated subsequently, starting with Sec. 328.

317. Remote-controlled Switches Are Used to control both lighting and power circuits. The principal use of remote-controlled switches for lighting service is in the control of large groups of lamps in such installations as public buildings, theatres (Div. 9), train sheds, isolated sections of plants or docks, factory buildings, and the like. Although switches of this type are frequently employed to provide control of a motor from a distant point, the material pertaining to remote-controlled switches which is contained in this division, applies principally to lighting-circuit control.

318. Remote-controlled Switches May Be Classified According To Operation as: (1) *Held closed mechanically* (Fig. 387); in the switches of this class, the switch is closed by one electromagnet and is held closed by a latch mechanism. Usually there is a second electromagnet which, when energized, releases the latch, whereupon the switch is opened by gravity, by a spring, or by the electromagnet. (2) *Held closed electrically* (Fig. 402); that is, in the switches of this class, the energization of the electromagnet closes the switch, and so long as current flows through this electromagnet, the switch (Fig. 385) is held, by the magnetic pull, in the closed position. Then if the current through the electromagnet is discontinued, the switch is opened by gravity or by a spring. This electromagnet may (Sec. 327) have two windings. Switches of each classification are described in the following sections.

Note.—An Electrically-held-closed Remote-controlled Switch Is Better Adapted For The Control Of Motors Than For The

Control Of Lamps. This is because such a switch (Sec. 327) inherently provides low-voltage protection to the load circuit. Thus, in the event of a failure in the power-supply, the current through the electromagnet will be discontinued; the switch will open; and the motor will be disconnected from the line.

Note.—A Mechanically-held-closed Remote-controlled Switch Is Better Adapted For Use In The Control Of Lamps Than Is One Which Is Held Closed Electrically. This is because: (1) *Low-voltage protection is usually neither required nor desired for lamps.* (2) *No current is wasted in holding the switch closed.*

319. The Two Principal Types Of Remote-controlled Switches are: (1) *The straight-line-movement type* (Fig. 386-*I*) wherein two movable contactors, *C*, which are carried by a U-shaped contact bar, *B*, in opening and closing, move inward and outward in a straight line. (2) *The clapper type* (Fig. 386-*II*) wherein the movable contactor, *C*, is carried by a contact finger, *B*, which in opening and closing, oscillates about the pivot, *P*. Electrically-held-closed switches (Sec. 318) and mechanically-held-closed switches (Sec. 318) of each of these types are described in following sections.

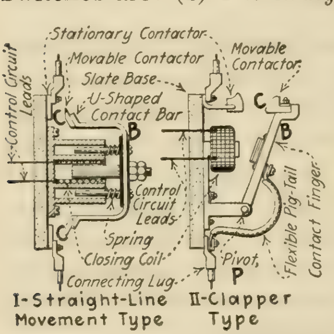


Fig. 386.—Illustrating two types of remote-controlled-switch construction. (Both switches are in the open position.)

320. A Three-pole, Straight-line-movement, Mechanically-held-closed Remote-controlled Switch is shown in Fig. 387. Except during the almost-instantaneous period of opening and closing, no current is required for the operation of this switch. This feature is provided by a device which, after the switch is closed, automatically opens the closing-coil circuit and closes the opening-coil circuit. Then, when the switch is opened, the opening-coil circuit is opened, and the closing-coil circuit, is closed. Therefore, when the switch is open, current can only flow through the closing-coil circuit. Or, when the switch is closed, current can only flow through the opening-coil circuit. Consequently, even if either of the momentary-contact switches (Fig. 388) be held closely inde-

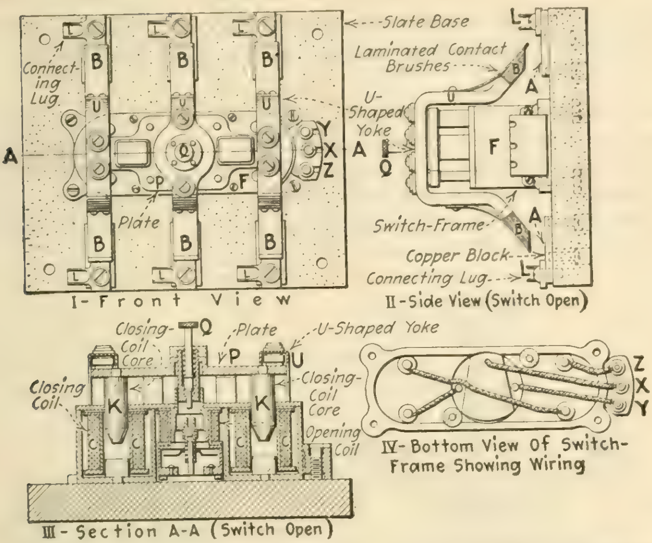


FIG. 387.—Three-pole remote-controlled switch of the straight-line movement type which is held closed mechanically. (*Type F, Hart Mfg. Co.*)

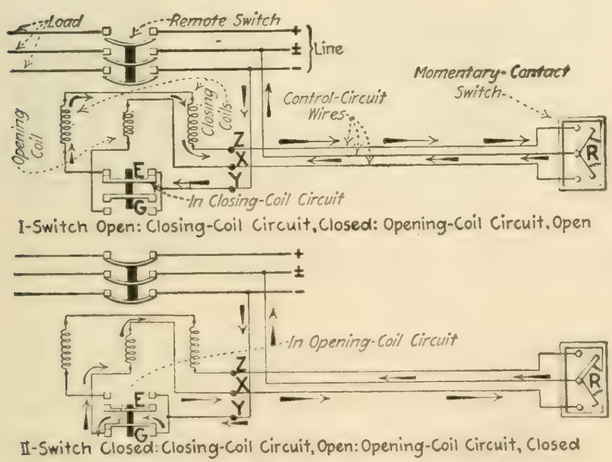


FIG. 388.—Wiring diagram of the opening and closing coils of a *Hart Type F* switch. (*Hart Mfg. Co.*)

finitely, no current will flow through the control circuit except during the very short period while the switch is opening or closing. The method of operation is explained below.

Explanation.—The switch (Fig. 387) is held in the open position by a spiral mainspring (not shown). When the switch is closed and locked this spiral mainspring is compressed. Then when the locking mechanism is released, the compressed mainspring kicks the switch open. The method of closing the switch and of releasing the locking mechanism is explained in the following paragraphs.

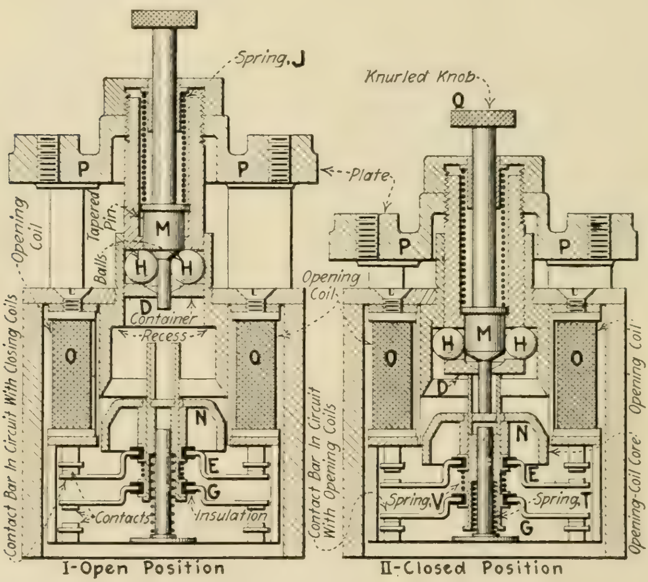


Fig. 389.—Illustrating locking mechanism and the method of connecting and disconnecting the opening and closing-coil circuit of *Hart Type F* remote-controlled switch.

The laminated contact brushes (*B*, Fig. 387) are carried by U-shaped yokes, *U*. These U-shaped yokes extend across the switch frame, *F*, and downward on either side of *F*, so that *B* may contact with the copper blocks, *A*, to which are bolted the connecting lugs, *L*. The brush yokes, *U*, are in turn carried by a plate, *P* (Figs. 387 and 389), to which are attached the cores, *K* (Fig. 387-*III*), of the closing coils. The switch is provided with two closing coils (*C*, Fig. 387-*III*) which are (Fig. 388) connected in series. Hence, when the closing coils, *C*, are energized, the

cores, K, are pulled downward, thus closing the switch. The current path through the closing coils is indicated by the arrows in Fig. 388-*I*.

When the switch closes, it is automatically locked closed as follows: Three steel balls (H, Fig. 389, only two of which are shown) are held in a container, D. The spring, J, is under compression and consequently pushes downward on the tapered-pin, M, which bears against the steel balls. The container, D, and the pin, M, are carried by the plate, P. As the switch is closed, P, M and D move downward until the balls slip outward under the edge of a fixed recess as shown in Fig. 389-*II*. When the balls slip into this recess, sufficient space is provided between them so that M, actuated by the spring, J, continues its downward movement to the position shown in Fig. 389-*II*. When M is in this position, the balls are held, partly under the edge of the recess and partly in the container D. Therefore, D cannot move upward. And since D is carried by the plate, P, the switch is locked closed.

As the movement of the pin M is continued downward by the spring, J, the lower end of M strikes the top of the opening coil core, N, and forces it downward. As N is forced downward, the contact bar, E, which is in circuit with the closing-coils (Fig. 388-*I*), is moved away from the contacts (Figs. 388-*II* and 389-*II*). Thus, the closing-coil circuit is opened. Also, as N is forced downward, the contact bar, G (Figs. 388-*II* and 389-*II*) closes the opening-coil circuit. Furthermore, this downward movement of N compresses spring T. Therefore, when the switch is closed, the closing-coil circuit is opened, and the opening-coil circuit is closed.

If the pin (M, Fig. 389-*II*) is now pushed upward, the balls, H, will slip out of the recess and the mainspring will snap the switch open. The pin, M, may be pushed upward manually by pulling on the knurled knob, Q. The pin, M, may also be pushed upward and the switch opened as follows: By closing the momentary-contact switch (R, Fig. 388-*II*), current will flow, as indicated by the arrows, through the opening coil (O, Fig. 389-*II*). The magnetic force thus exerted by O raises the opening-coil core, N (Fig. 389-*II*), and pushes M upward. The balls, H, are thereby disengaged from the recess and the switch opens. When N begins its upward movement, spring V acts to hold the contact bar, G, downward, so that the opening-coil circuit is kept closed until the switch is unlocked. When the switch is unlocked it opens, and spring T raises bars E and G to the position shown in Fig. 389-*I*. Thus the opening-coil circuit is opened and the closing-coil circuit is closed so that all is in readiness for the next operation of the switch

321. Table Showing Currents Required To Operate Type F Remote-controlled Switches. (*Hart Mfg. Co.*)

Size of switch	Control circuits	Closing coils, amp.	Opening coil, amp.
30, 60, and 75 amp. 2-, 3-, or 4-pole	15 V., D.C.	6.5	13.0
	30 V., D.C.	5.2	7.5
	50 V., D.C.	3.2	4.5
	125 V., D.C.	2.2	4.6
	250 V., D.C.	1.7	1.2
	[1]125 V., A.C.	2.2	0.5
	[1]250 V., A.C.	1.1	0.25
	[1]440 V., A.C.	0.55	0.13
100, 150, and 200 amp., 2-, 3-, or 4-pole	125 V., D.C.	2.3	5.0
	250 V., D.C.	1.25	2.0
	[1]125 V., A.C.	9.0	1.5
	[1]250 V., A.C.	3.5	3.7
	[1]440 V., A.C.	1.8	1.2

[1] 60 cycles.

NOTE.—THESE SWITCHES WILL OPERATE SATISFACTORILY AT APPROXIMATELY 15 PER CENT. ABOVE AND BELOW THEIR RESPECTIVE VOLTAGE RATINGS. That is, a switch which is rated at 110 volts will operate satisfactorily at 95 or 125 volts.

322. A Mechanically-held-closed Remote-controlled Switch Of The Clapper Type is shown in Figs. 390 and 391. Switches of this type are regularly manufactured (Fig. 392) with one, two, and three poles. Pressing the "close" button of the momentary-contact switch (*M*, Fig. 393) energizes the closing coil (*A*, Fig. 390). The magnetic pull thus exerted closes the switch and it is automatically locked. Then, by pressing the "open" button (*M*, Fig. 393), the opening coil, (*B*, Fig. 390) is energized. This releases the lock and the switch is opened by gravity. As long as either one of the momentary-contact switches (*M*, Fig. 393) is held closed, current will continue to flow through the coil which is controlled (Sec. 329) by that switch. However, current-flow through the coil will cease as soon as the momentary-contact

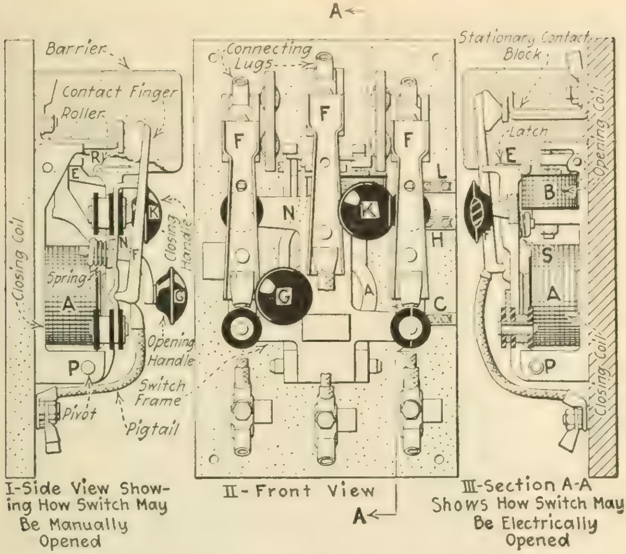


Fig. 390.—Three-pole, mechanically-held-closed, remote-controlled switch of the clapper type. (*Cutler-Hammer Mfg. Co.*)

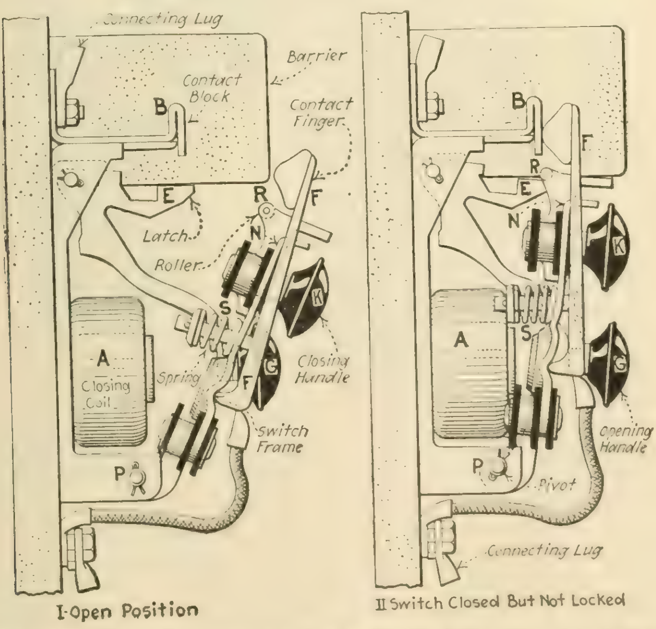


Fig. 391.—Illustrating method of closing and locking of a mechanically-held-closed remote-controlled switch, simplified for purposes of illustration. (*Cutler-Hammer Mfg. Co.*)

switch is permitted to open. The operation is explained in detail below.

EXPLANATION.—Corresponding parts in Figs. 390 and 391 are designated by the same reference letters. The switch is shown in the open position in Fig. 391-*I*. The contact finger, *F*, is secured to the switch

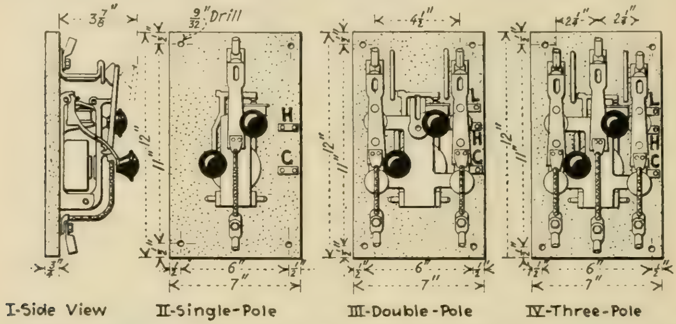


FIG. 392.—Drilling dimensions of single-, double-, and three-pole remote-controlled switches. (Clearance dimensions as shown in side view are the same for each switch shown in *II*, *III* and *IV*. *Cutler-Hammer Mfg. Co.*)

frame, *N*, by a bolt and the spiral spring, *S*. The switch frame rotates from the open to the closed position, and *vice versa*, about the pivot, *P*. When the closing-coil, *A*, is energized, the magnetic force moves the switch frame, *N*, and the contact finger, *F*, to the position shown in Fig. 391-*II*. At this point of the switch-frame travel, *F* is stopped by striking the contact-block, *B*. However, the magnetic force of *A* is still acting on the frame *N*. This force compresses the spring, *S*, and moves

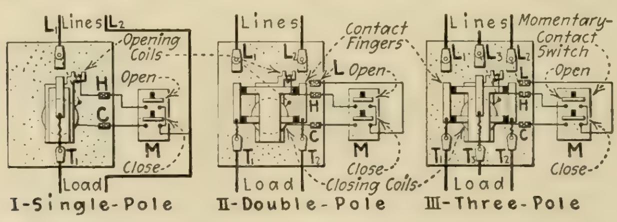


FIG. 393.—Remote-controlled-switch wiring diagrams. (*Cutler-Hammer Mfg. Co.*)

N onward to the left, so that the notch in the latch, *E*, engages the roller, *R* (Fig. 390-*I*), which is carried by the frame, *N*. The switch is now closed and locked closed. The same operation may be manually performed by pushing to the left (Fig. 391) on the closing handle, *K*.

Energizing the opening coil, *B* (Fig. 390-*III*) exerts a downward pull on the latch, *E*. This disengages *E* from the roller. The spring *S* now expands and moves the frame back to the position shown in Fig. 391-*II*, whereupon the switch is opened by gravity. The switch is manually

opened as follows: Pushing to the left (Fig. 390-*I*) on the opening handle, *G*, causes the latch, *E*, to move downward. Thereafter, the switch is opened in the same manner as that explained above for the electrical operation.

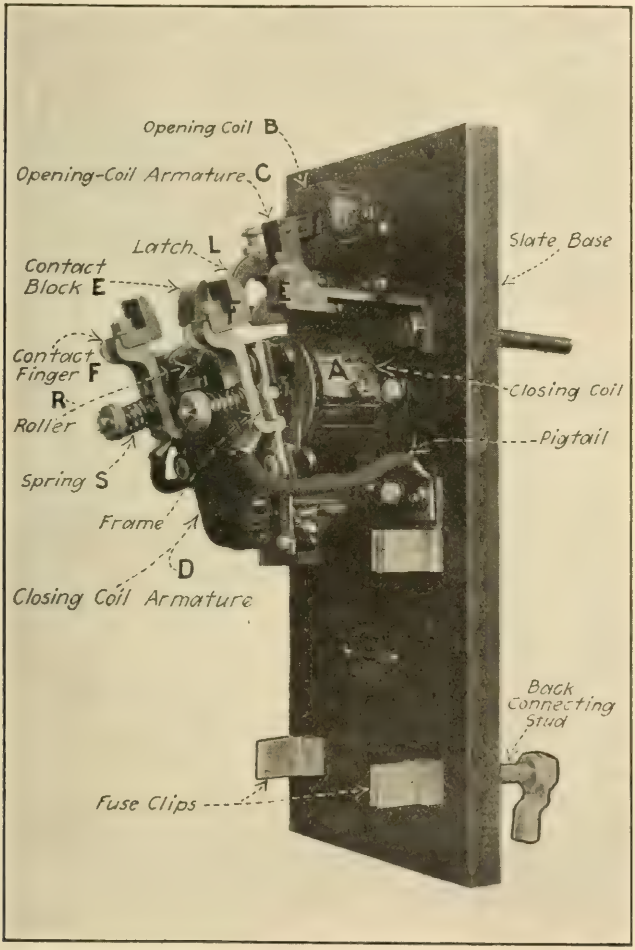


FIG. 394.—Two-pole, mechanically held-closed remote-controlled switch of the clapper type. (*Frank Adam Electric Co.*)

323. The Major Remote-controlled Switch (Figs. 394, 395, and 396) is a mechanically-held-closed switch of the clapper type. The general construction and operation of this switch

is similar to that of the switch of Figs. 390, 391 and 393; the differences are enumerated below. Current will flow through the opening and closing coils (*B* and *A*) as long as the controlling momentary-contact switch (*M*, Fig. 396) is held closed. Since the coils in this particular switch are designed for continuous duty. no damage to them will be caused, even if the

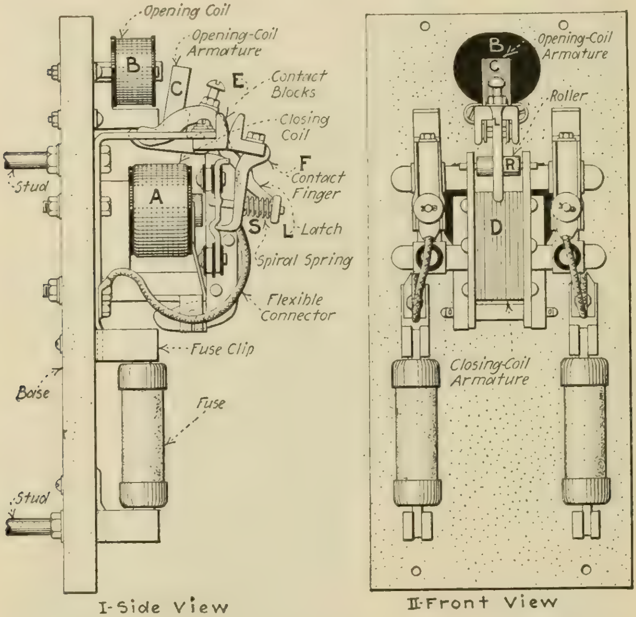


Fig. 395.—The *Major* remote-controlled switch. (*Frank Adam Electric Co.*)

current-flow is permitted to continue indefinitely. This switch is of very rugged construction. It is therefore well suited for theatre service (Div. 9) where frequent operation is required. The method of operation is explained below.

Explanation.—Those reference letters which appear in each of Figs. 394, 395 and 396 are used to designate corresponding parts. This switch is similar in construction to that described in Sec. 322. Each contact finger, *F*, is secured to the switch frame by a bolt and a spiral spring (*S*, Figs. 394 and 395). When the switch is being closed, the contact fingers, *F*, strike the contact blocks, *E*, before the latch, *L*, engages the roller, *R*. Then, the continued magnetic force of the closing

coil, A, on the closing-coil armature, D, compresses spring S, and pulls the frame onward. As soon as R, which is carried by the switch frame, moves to the position corresponding to that shown in Fig. 396-*I*, the latch, L, is pulled downward by gravity and engages the roller, R. Thus, the switch is closed and locked closed.

Now, by closing the opening-switch of the two-circuit momentary-contact switch (M, Fig. 396) the opening coil, B is energized. The magnetic force which is thereby exerted on the opening-coil armature, C, raises the latch, L, from the roller, R. The switch frame being thus released, spring S expands. Then, the momentum, which is given to the switch frame by the sudden expansion of S, together with gravity causes the switch to open. The switch may be manually closed by pushing inward on the closing-coil armature (D, Fig. 394). The switch may be manually opened by raising latch L with the finger. No handles are provided.

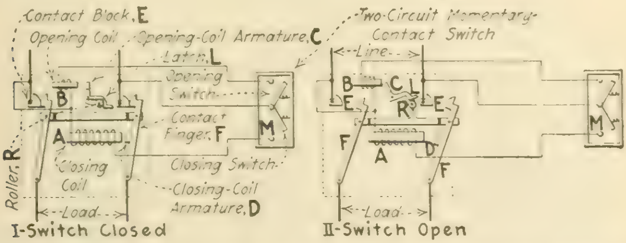


Fig. 396.—Illustrating the operation of the *Major* remote-controlled switch. (*Frank Adam Electric Co.*)

Note.—The Voltage And Current Ratings Of The Major Switch are these: This switch, as regularly manufactured, is designed to control a load-circuit current of 100 amp. at 250 volts. The slate base is ordinarily drilled so that either 100-, 60-, or 30-amp. fuse clips may be secured thereto. When the switch is electrically operated, the maximum values of the current which flow through the opening and closing coils are: (1) *Alternating current;* 7.7 amp. for closing, and 2.1 amp. for opening. (2) *Direct current;* 2 amp. for closing, and 0.5 amp. for opening. Since the time during which this operating current flows is so short that it may be considered almost instantaneous, only a very small amount of energy is required to electrically open and close the switch from a remote location.

324. A Two-pole, Mechanically-held-closed Remote-controlled Switch Of The Clapper Type is shown in Fig. 397. The plane of movement of the contact fingers, F, is parallel to the switch base. There is only one coil, C, which serves both to open and close the switch. No current flows through this

coil except during operation. The method of operation is explained below.

Explanation.—The two contact fingers (*F* Fig. 397) are connected by an insulated plate, *M*. This plate is connected to the lower end of

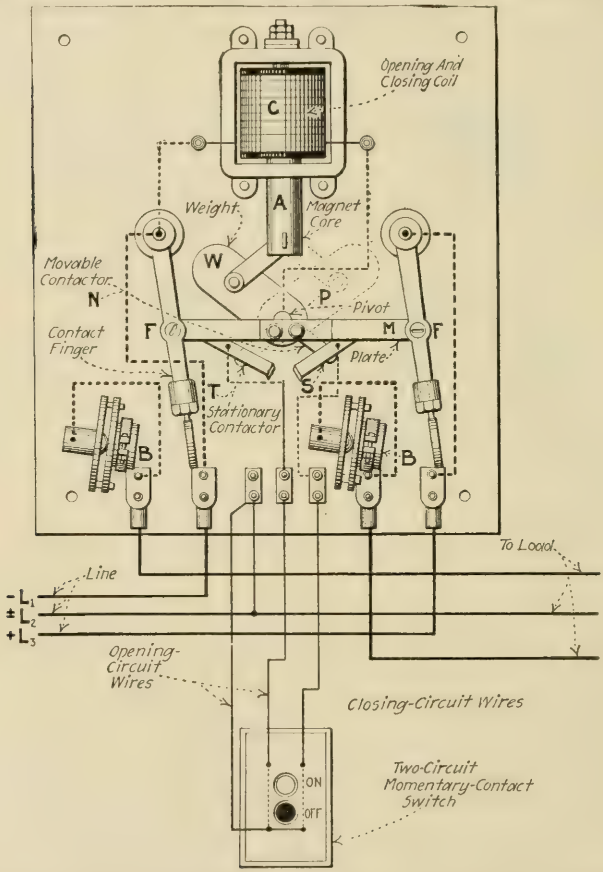


Fig. 397.—Two-pole mechanically-held-closed remote-controlled switch of the clapper type. (*Automatic Switch Co.*)

the weight, *W*, which oscillates about the pivot, *P*. The magnet core, *A*, is connected through a link to the upper end of *W* so that when *A* is jerked upward by the electromagnet, *C*, it passes over the center and drops by gravity to the dotted position, thus closing the switch. The lower end of *W* is provided with a movable contactor, *N*. When the switch is in the open position (Fig. 397), *N* contacts with the stationary

contactor S. Now by pressing the "on" button of the momentary-contact switch, the circuit through the electromagnet is completed, the core is jerked upward and the switch is closed as explained above. The circuit thus formed by pressing the button may be traced as follows: From L_1 through C to the pivot of W, through W and the movable contactor, N, to the stationary contactor, S, and from S through the momentary contact switch to the neutral, L_2. When the switch is closed the movable contactor, N, as shown by the dotted position, now contacts with stationary contactor T. Then by pressing the "off" button of the momentary-contact switch, C will be energized and the switch will be operated back to the open position. The circuit formed by pressing the "off" button may be readily traced by referring to Fig. 397.

325. Another Mechanically-held-closed Remote-controlled Switch Of The Clapper Type is illustrated in Fig. 398. When

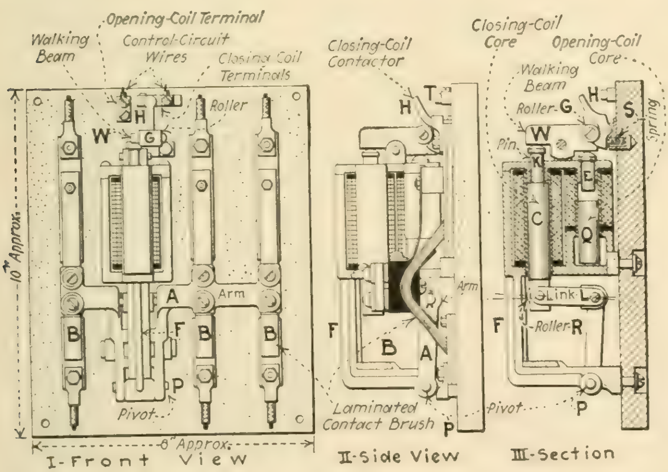


FIG. 398.—Three-pole, mechanically-held-closed, remote-controlled switch. (*Sundh Electric Co., Bul.* 7200.)

the switch is closed (Fig. 398-*II*), the laminated brushes, B, bridge the upper and lower contact blocks, thus completing the circuit through the switch. When the switch is opened the brushes fall outward. The method of operation is explained below.

EXPLANATION.—In Fig. 398, the laminated brushes, B are secured to the arm, A, which is pivoted to the switch frame, F, at P. In opening and closing the switch, the arm, A, oscillates about the pivot, P. The roller (R, Fig. 398-*III*) is carried by the lower end of the closing-coil

core, C. When C is raised by the closing coil or lowered by gravity, R rolls up or down along the inner side of the switch frame, F. (The contact brushes and a portion of the arm are omitted in *III*). The same pivot which carries R also carries one end of the link, L. The other end of L is connected to the arm (A, Fig. 398-*III*) at D. Thus, by raising and lowering the closing-coil core, C, the arm is caused to oscillate about P, thereby closing and opening the switch. When the roller, R is pulled upward beyond the lower center-line (Fig. 398-*III*), the spring action of the brushes, B, acting through the arm, A, and the link, L, tends to push the core upward still further. But the core is now at the upper end of its travel and can move no further upward. Therefore, the switch is, by virtue of R and L being "off center," locked closed. When the core is pushed downward, so that the center of R passes below the lower center-line, R is free to roll down the side of F, and the switch opens.

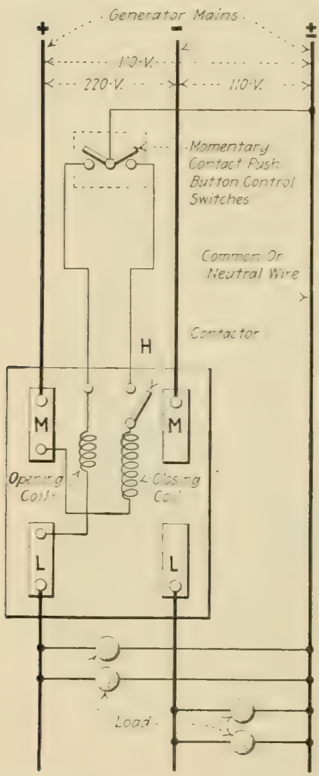


FIG. 399.—Wiring diagram of mechanically held-closed remote controlled switch. (The mains are connected to terminals marked *M*; the oening coil to terminal *L*; the closing coil is connected to terminal *M*. *Sundh Electric Co., Bul.* 7200.)

In Fig. 398-*II*, the switch is in the closed position. By closing the momentary-contact switch (Fig. 399) which controls the opening-coil circuit, the opening coil is energized, and the opening-coil core (O, Fig. 398-*III*) is raised. When O is raised, it strikes the pin, E, thus raising the right-hand end of the walking beam, W, and forcing down the left-hand end of W. When the left-hand end of W is lowered, it strikes pin, F, thereby pushing the core, C, downward. This moves R downward, and unlocks it and the switch is opened, as explained above. As will be apparent from a study of Fig. 399 when the remote-controlled switch is open, the opening coil cannot be energized. Also, as the right-hand end of the walking beam, W, is tilted upward, the roller, G, permits the spring, S, to push the lower end of the closing-coil contactor, H, to the left. Thus, the upper end of H is caused to move to the right and contact with two small pilot contacts on T, thereby closing the closing-coil circuit.

When the closing coil is energized by closing its momentary-contact switch (Fig. 399), the core C is raised. The switch is closed and locked closed as explained above. Also, when C is raised, the left-hand end of the walking beam, W, is, by the pin F, tilted upward. Consequently, the right-hand end of W tilts downward. Thus, as will be apparent from the illustration (Fig. 398-*III*), the roller, G which is carried by W,

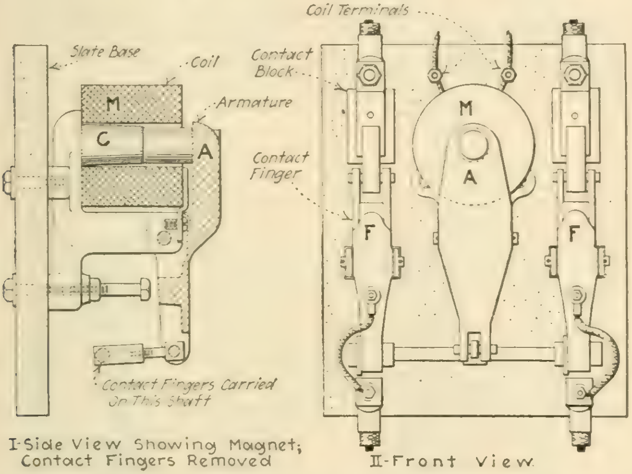


FIG. 400.—Two-pole, electrically-held-closed remote-controlled switch of the clapper type. (*Sundh Electric Co.*)

causes the upper end of H to move to the left. The closing-coil circuit is thereby opened as soon as the switch is closed.

326. An Electrically-held-closed Clapper Type Of Remote-controlled Switch is illustrated in Fig. 400. Switches of this type are sometimes called *magnetic switches*, or *magnetic*

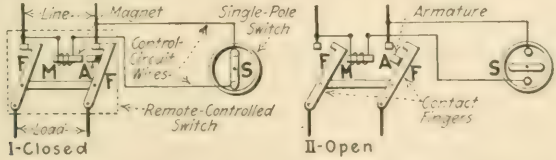


FIG. 401.—Control-circuit diagram for electrically-held-closed remote controlled switch.

contactors. As indicated in Fig. 401, current must, to hold the switch closed, flow through the magnet, M. Closing switch S (Fig. 401-*II*) energizes M. The armature A is thereby attracted, and the contact fingers, F, are pulled to the closed

position (Fig. 401-*I*). If *S* is opened, or if the service is interrupted, *M* will become de-energized and the switch will be opened by gravity. If the switch is opened by an interruption in the voltage supply, it will be reclosed upon resumption of service.

327. A Two-pole, Electrically-held-closed, Straight-line-movement Remote-controlled Switch is shown in Fig. 402. Although this switch is specially adapted for the control of motors, it may be used to control lighting circuits. Remote-

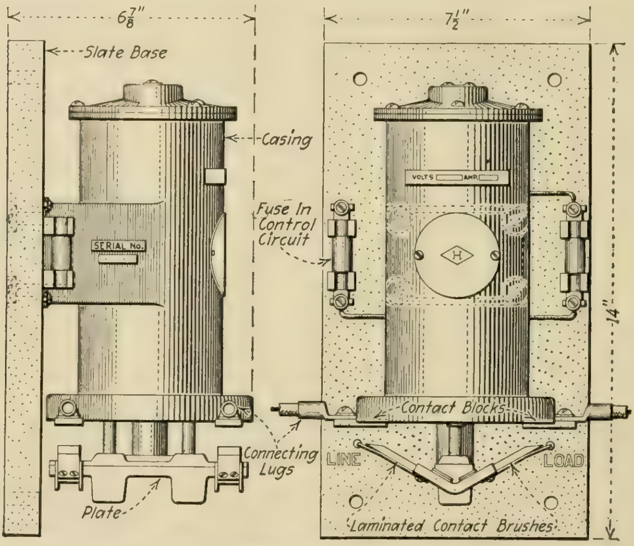


FIG. 402.—Two-pole, electrically-held-closed remote-controlled switch. The switch is shown in the open position. (*Type A, Hart Mfg. Co.*)

controlled switches of this type are so made that they may be controlled (Sec. 322) either by momentary-contact switches, single-pole switches or three- and four-way switches. When this switch (Fig. 402) closes, it is mechanically locked closed. However, as explained below, a small current is required to prevent it from unlocking and opening.

EXPLANATION.—By closing the single-pole switch (*S*, Fig. 403-*I*), the closing coil, *A*, is energized. This raises the remote-controlled switch, *R*, to the closed position shown in *II*. As *R* is being closed, the following operations occur almost simultaneously: (1) *The switch is locked in the*

closed position. (2) *The holding coil, B, is energized.* (3) *The core of B is lifted, thereby disconnecting the closing coil, A, from the circuit.* As long as the proper voltage is maintained between C and D (Fig. 403-*II*), the current through B will hold the core of B upward in the position shown. If the current-flow between C and D is interrupted, either by a

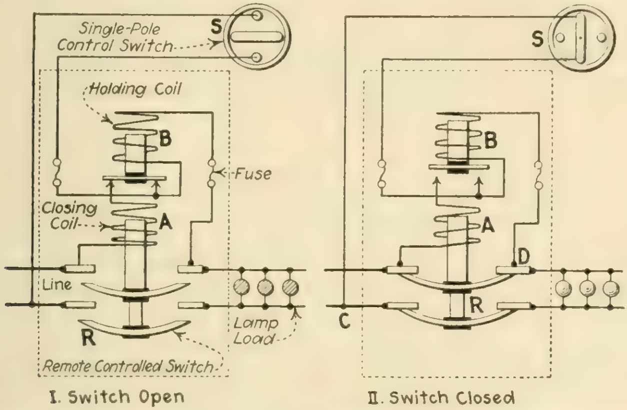


FIG. 403.—Illustrating operation of a *Hart Mfg. Co. Type A* remote-controlled switch. (The fuses shown herein are for protection of the coils.)

failure in the power supply, or by opening S, B will be de-energized, and its core will drop. The switch mechanism is so designed that when the core of B drops, the locking device is tripped, thus permitting R to open. If R is opened due to a power-supply failure, it will, provided S remains closed, reclose upon resumption of service (see also Sec. 322).

328. The Control Circuits Of A Remote-controlled Switch are those circuits which carry the current for opening and

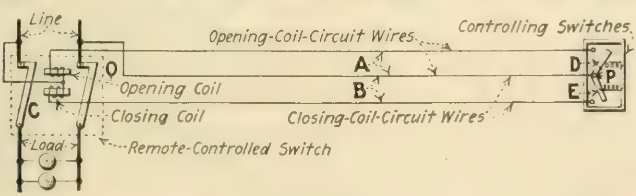


FIG. 404.—Illustrating the control circuit of a remote-controlled switch.

closing it. The control circuits consist of: (1) *The opening and closing coils, O and C,* Fig. 404, which are mounted on the remote-controlled switch. (2) *One or more controlling switches, D* and *E*, Fig. 404, which are installed at the control locations. (3) *The wires, A and B,* (Fig. 404) *which connect the opening and*

closing coils to the controlling switch. The control-circuit connections and the type of the controlling switches which are used in the control circuit will usually depend upon the type of the remote-controlled switch. In general, the mechanically-held-closed switches are controlled (Sec. 329) by momentary-contact switches, and the electrically-held-closed switches are controlled (Sec. 322) by single-pole, or three- and four-way switches. Control-circuit diagrams for remote-controlled switches of various types are described in the following sections.

NOTE.—THE SIZE OF THE CONTROL-CIRCUIT WIRES FOR A REMOTE-CONTROLLED SWITCH can not be smaller than No. 14, B. & S. gage to insure compliance with the CODE. Ordinarily No. 14 is sufficiently large to carry the current. See Table 321 for control currents required to operate Hart remote-controlled switches, which are in general typical of the currents required to operate the remote-controlled switches of other makes. See Sec. 323 for currents required to operate the major remote-controlled switch. If the control-circuit is excessively long, the size of the wire used for it must be sufficiently large that the voltage drop in it will not exceed about 15 per cent.

329. Remote-controlled Switches Of The Mechanically-held-closed Type Are Generally Controlled By Momentary-contact Switches. Two momentary-contact switches (*D* and *E*, Fig. 404) are usually required: One for the opening-coil circuit and one for the closing-coil circuit. Therefore, for economy of installation, two momentary-contact switches which are contained in the same porcelain casing (Figs. 79 and 405) and which have a common binding-post (*P*, Fig. 404) are ordinarily employed for the control of this type of remote-controlled switch.

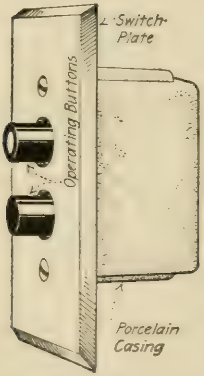


FIG. 405.—Two-circuit push-button, momentary-contact snap switch. (*Cutler-Hammer Mfg. Co.*)

NOTE.—CIRCUIT DIAGRAMS FOR SINGLE-LOCATION CONTROL OF REMOTE-CONTROLLED SWITCHES BY MEANS OF MOMENTARY-CONTACT SWITCHES are shown in Figs. 388, 393, 396 and 397.

330. Multi-location Control May, For Those Remote-controlled Switches Which Can Be Operated By A Momen-

tary-contact Switch, Be Obtained as shown in Figs. 406 and 407. As indicated in Figs. 388, 393, 396, and 397, the connections for the momentary-contact switch will be somewhat

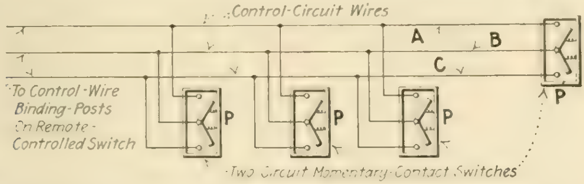


FIG. 406.—Showing connections of two-circuit momentary-contact switches for multi-location control of remote-controlled switches.

different for the various remote-controlled switches. Therefore, when it is desired to provide more than one control location for a momentary-contact-controlled remote-controlled switch, first determine the correct connections for single-location control (Sec. 329). Then install a two-circuit momentary-contact switch at each desired control location. Connect the common binding-post (*P*, Fig. 406) of each momentary-contact switch to the same wire, *B*, Fig. 406. Connect one of the remaining binding-posts of each switch to a second wire, as *A*, and connect the other binding-post of each switch to the third wire, *C*.

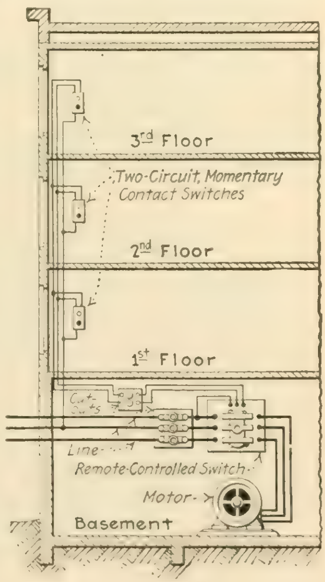


FIG. 407.—For remote control of a vacuum cleaner motor controlled on each floor by momentary-contact switches connected in parallel. (*Hart Mfg. Co., Catalog F.*)

331. A Considerable Wire Saving May Frequently Be Effected In A Remote-control Installation By Using A Common Wire For All Momentary-contact Switches as shown in Fig. 408. The common control wire (*W*, Fig. 408) is connected to one side of the main and to the center contact (*P*, Fig. 406) of all of the two-circuit momentary contact switches. The

other two terminals of each momentary-contact switch are connected, one to one end of the opening coil, O, and one to one end of the closing coil, C. The other ends of each O and C are connected to the other side of the main. The control circuit of each remote-controlled switch may be readily traced

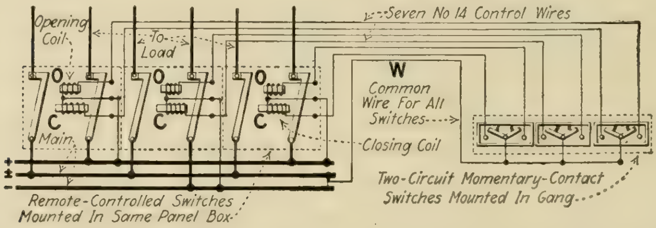


FIG. 408.—Showing how a wire-saving may be effected by using a common wire for all momentary-contact switches. (See Sec. 337 as to fusing of control-circuit wires.)

by referring to Fig. 408. This method of connections may (see note below for limitations) be used with practically any mechanically-held-closed remote-controlled switch. It is especially suitable for those installations wherein a number of remote-controlled switches (Fig. 409) are mounted on the

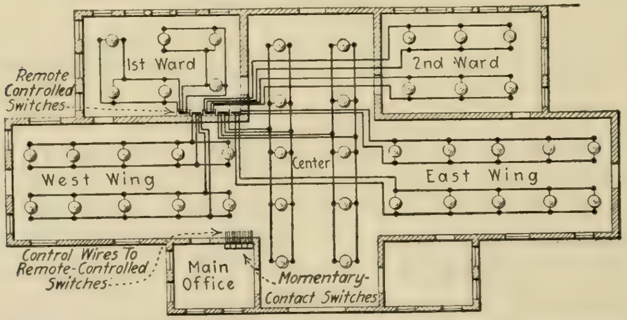


FIG. 409.—Remote-control system for the lights on one floor of a hospital.

same panel board, and where the controlling switches therefor are mounted in gang at one control location. *The wire-saving which will then be effected by this method over the ordinary method shown in Fig.* 406 = (*the number of remote-controlled switches* -1) $\times$ (*the average distance between the momentary-contact switches and the remote-controlled switches*).

NOTE.—A COMMON MOMENTARY-CONTACT-SWITCH WIRE MAY NOT BE DESIRABLE FOR ALL REMOTE CONTROLLED SWITCH INSTALLATIONS. Where the momentary-contact switches are not grouped at a single location but instead are distributed at a number of different locations throughout the building, a common wire should not, usually, be employed. The reason for this is that trouble—a ground for example—at any point on the long common wire might throw trouble on all of the momentary-contact-switch circuits. If this occurred, the trouble would probably be difficult to locate and correct, because of the great length and the ramifications of the common wire. Hence, where the momentary-contact switches are not grouped, the wiring arrangement shown in Fig. 410 is usually preferable. Before installing a system wired as in Fig. 408, it would be advisable to obtain the approval of the local wiring

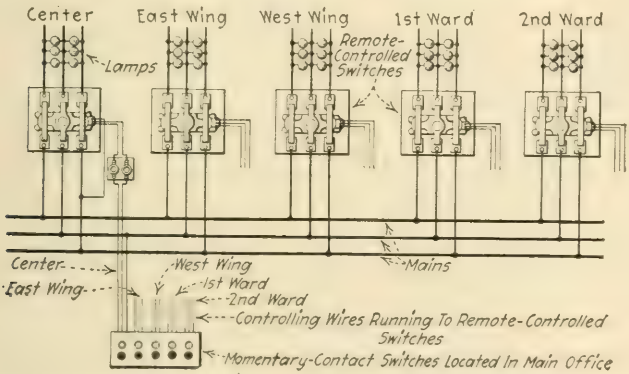


FIG. 410.—Wiring-diagram of a remote control system wherein five remote-controlled switches are employed. (*Hart Mfg. Co., Catalog F.*)

inspector; while there appears to be no CODE rule which this wiring would violate, there might be some local requirement with which it would conflict.

EXAMPLE.—A REMOTE-CONTROL SYSTEM FOR THE LIGHTS ON ONE FLOOR OF A HOSPITAL is shown in Fig. 409. The lights in each of the various wings and in each of the wards are controlled by the momentary-contact switches located in the main office. The wiring diagram as indicated in Fig. 410, requires, for each remote-controlled switch, three control wires extending from the momentary-contact switches to the remote-controlled switches. By arranging the connections as indicated in Fig. 408, four of these control wires may be eliminated. Assume that it is 50 ft. from the momentary contact-switches to the remote-controlled switches. Then according to the rule stated above, since there are five remote-controlled switches, *the wire-saving which will be effected* = $(5 - 1) \times 50 = 200$ *ft. of No.* 14 *wire.*

332. Multi-location Control For Those Remote-controlled Switches Which Are Operated By Single-pole Switches (Figs. 401 and 403) may be obtained by substituting the

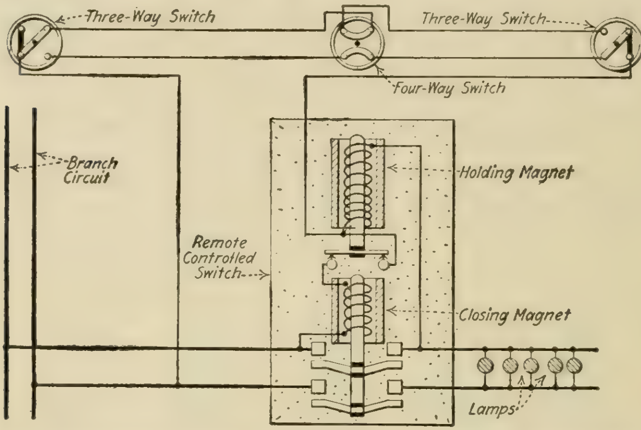


Fig. 411.—Multi-location control of an electrically-held-closed remote-controlled switch using three- and four-way snap switches. (*Hart Mfg. Co., Type A.*)

required number of three- and four-way switches (Fig. 411) for the single-pole switch of Fig. 403.

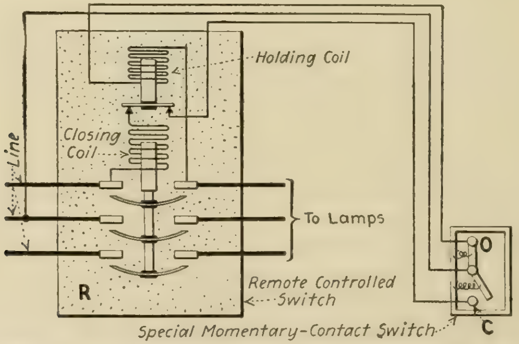


Fig. 412.—Special momentary-contact switch used to operate an electrically-held-closed remote-controlled switch. (*Hart Mfg. Co., Type A.*)

Note.—The Electrically-held-closed Switch Shown In Fig. 403 May Be Controlled By A Momentary-contact Switch by making the connections as shown in Fig. 412. A special two-circuit momentary-contact switch (*Hart Mfg. Co., List No.* 093) is required. This switch has one side, *O* (Fig. 412) normally closed, and one side,

C, normally open. With the remote-controlled switch, R, in the open position, closing switch C closes R. When R closes, it locks and disconnects the closing coil as explained in Sec. 327. The control circuit through the holding coil is then made through the momentary-contact switch, O. If O is opened the holding coil is de-energized and switch R opens. If R opens because of a power-supply failure, it will not reclose upon resumption of service until switch C is operated.

333. Two Or More Remote-controlled Switches May Be Operated By One Two-circuit Momentary-contact Switch by arranging the control-circuit connections as indicated in Fig. 413. If the switches A and B are closed, operation of switch N will simultaneously open A and B. If A and B are open, operation of M will simultaneously close both A and B. Additional remote-controlled switches may, by connecting their opening and closing coils to wires D, E and F in the manner indicated in Fig. 413, be controlled by MN. The maximum number of switches which may be so controlled will be governed by the safe current-carrying capacity or by the safe current-breaking capacity of MN. That is, the product of the number of remote-controlled switches by the current-value in amperes which is required to close one switch should not exceed the safe current-carrying or the safe current-breaking capacity of MN (see examples below).

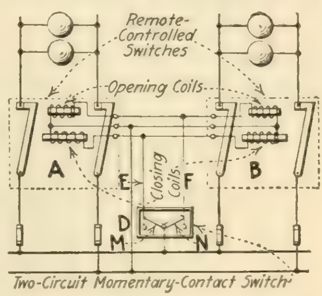


FIG. 413.—Circuit diagram for controlling two remote-controlled switches with one two-circuit momentary-contact switch.

EXAMPLE.—Assume that a current of 5 amp. is required to close one remote-controlled switch, and that the closing-current of each switch is interrupted (Secs. 320 and 325) by the remote-controlled switch mechanism. Then if five remote-controlled switches are to be operated by one momentary-contact switch (MN, Fig. 413) *the rated current-carrying capacity of MN should be at least:* $5 \times 5 = 25$ *amp.*

EXAMPLE.—Assume that the remote-controlled switches are of a type (Secs. 322 and 323) wherein the operating current is broken by the momentary-contact switch. Then the maximum number of remote-controlled switches which should be controlled by one momentary-contact switch will be governed by the maximum current which can be safely

broken by the momentary-contact switch without causing excessive damage to its contacts. That is, assume that a controlling switch has a continuous-duty rating of, say, 60 amp.; but with frequent operation, 45 amp. is the maximum current which this switch will interrupt without causing serious damage to its contacts. Then, if the minimum current required to close each remote-controlled switch is 7 amp., not more than ($45 \div 7 = 6.4$) six remote-controlled switches should be connected to one of these momentary-contact switches.

334. Manual Double-throw-Switch Operation Of Two Mechanically-held-closed, Remote-controlled Switches May Be Provided as shown in Fig. 414. Remote restricted control (Sec. 15) of lamp-groups *C* and *D* is thereby provided, as explained below, by the two-circuit momentary-contact switch, *MN*.

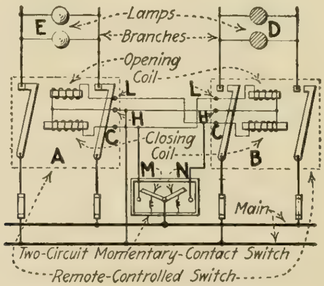


FIG. 414.—Circuit diagram for two mechanically-held-closed, remote-controlled switches connected for manual double-throw switch operation.

EXPLANATION.—If both switches *A* and *B* are open, operating switch *N* will close *B*; or operating switch *M* will close *A*. If both switches *A* and *B* are closed, operating *N* will open *A*; or operating *M* will open *B*. If *A* is closed and *B* is open, operating *N* will open *A* and close *B*. If *B* is closed and *A* is open, operating *M* will open *B* and close *A*. Switches *A* and *B* cannot be simultaneously opened or simultaneously closed by *MN*. Therefore, if it is desired that both lamp-groups, *C* and *D*, be either lighted or extinguished at the same time, one of the switches, *A* or *B*, must be manually opened or closed.

335. Automatic Double-throw-switch Operation Of Two Mechanically-held-closed, Remote-controlled Switches May Be Provided By A Relay as shown in Figs. 415 and 416. The relay so operates that if the *regular service* fails the load circuit will be automatically connected to the *emergency service*. Then, if the power-supply of the regular service is re-estab-

lished, the load circuit will be automatically reconnected thereto. Such an arrangement is sometimes used in theatres (Sec. 391) in connection with the emergency lights. The regular service (Figs. 415 and 416) is connected to a main or feeder of a public lighting company. The emergency service may be connected to either a storage battery, a continuously-operating isolated plant, another main belonging to the same lighting company, or to a main belonging to a different lighting

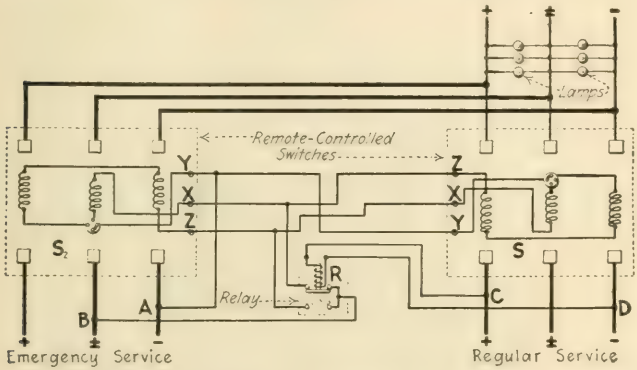


FIG. 415.—Two remote-controlled switches so operated by a relay that if the regular service fails, the load will be automatically transferred to the emergency service. (*Type F, Hart Mfg. Co.*)

company. As explained below, control of switches S_1 and S_2 (Fig. 415) from a distant location is not provided. By connecting a double-pole snap-switch (*D*, Fig. 417) into the control circuit of Fig. 415, remote control of switches S_1 and S_2 is provided as explained below.

EXPLANATION.—The operation of the remote-controlled switches of Figs. 415 and 416 is explained in Secs. 320 and 324, an understanding of which, will facilitate the tracing out of the circuits of Figs. 415 and 416. As long as the voltage-supply of the regular service (Fig. 415) is maintained, current flows from *C* to *D* through the coil of the relay, *R*, and *R* is held in the position shown in full lines. If the voltage supply of the regular service is interrupted, the current through the coil of *R* is discontinued, and the contactor of *R* drops to the position indicated by the dotted lines. This closes the control circuits (see Sec. 320) of S_1 and S_2 thereby opening S_1 and closing S_2. These control circuits are fed from the emergency-service circuit at *A* and *B*. Then, when the voltage

of the regular service is re-established, R is again raised to the position indicated by the full lines. Thus S_2 is opened and S_1 is closed.

In Fig. 417, connections are shown for controlling S_1 and S_2 from a remote location, D By closing the double-pole switch (D, Fig. 417), the lamps will, even though both the emergency and regular services are operative, be lighted from the regular service. If the regular service is inoperative, closing switch D will close S_2, and the current which is

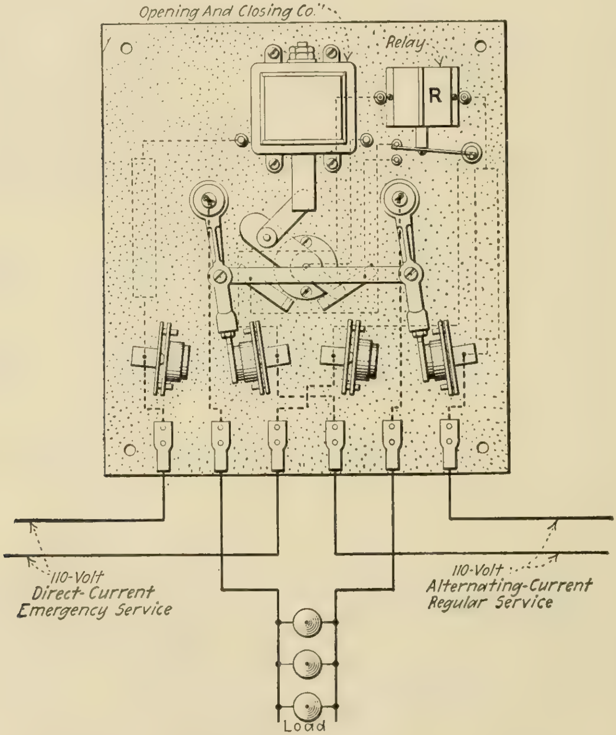


FIG. 416.—Double-pole, double-throw switch which is so operated by a relay that if the regular service fails the load will be automatically transferred to the emergency service. (*Automatic Switch Co.*)

required for lighting the lamps will be supplied by the emergency service. Opening D will, if current is being supplied to the lamps from the regular service, extinguish them. But if D is opened while the current for lighting the lamps is being supplied by the emergency service, the lamps will not be extinguished. As long as D is closed, the operation of the switches S_1 and S_2 will be identical to that explained above in connection with Fig. 415.

NOTE.—TWO TYPE F SWITCHES AS ARRANGED FOR AUTOMATIC DOUBLE-THROW OR THROW-OVER OPERATION by the Hart Mfg. Co. are

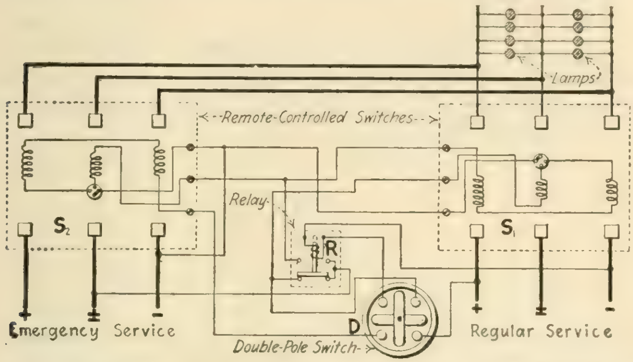


FIG. 417.—Two *Diamond "H," Type F* switches, with relay control for automatic transfer from regular service to emergency service, which have a double-pole switch, *D*, so connected into the control circuit that control of the switches S_1 and S_2 from a remote location is obtained thereby. (Remote-controlled switches are *Type F, Hart Mfg. Co.*)

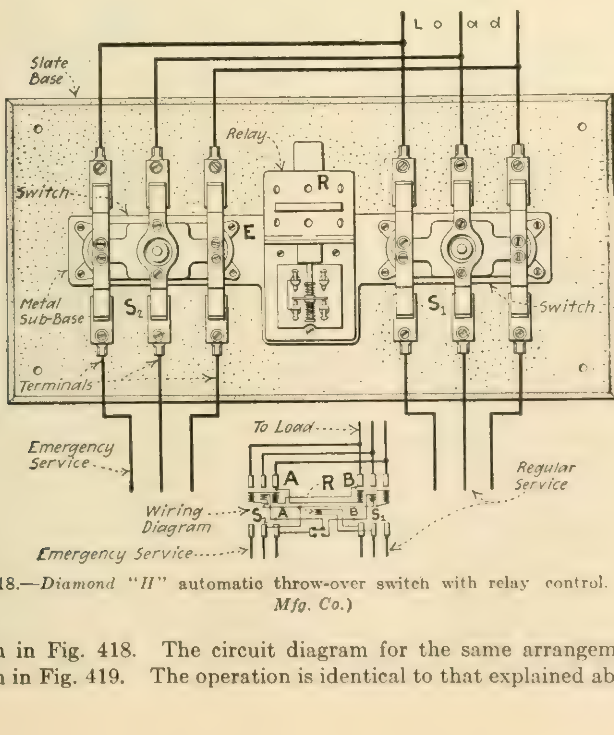


FIG. 418.—*Diamond "H"* automatic throw-over switch with relay control. (*Hart Mfg. Co.*)

shown in Fig. 418. The circuit diagram for the same arrangement is shown in Fig. 419. The operation is identical to that explained above in

connection with Fig. 415. The contacts *AA* and *BB* (Figs. 418 and 419) are mounted at the sides of the switch frames. These contacts are only in circuit when the switch upon which they are mounted is open. Their purpose is to preclude the possibility of one switch closing before the other has opened. Their method of operation to prevent this may be understood from a study of Fig. 419. All wiring indicated by the light lines (Fig. 419) is provided and connected by the manufacturer, and is contained within the metal sub-base, *E*, Fig. 418.

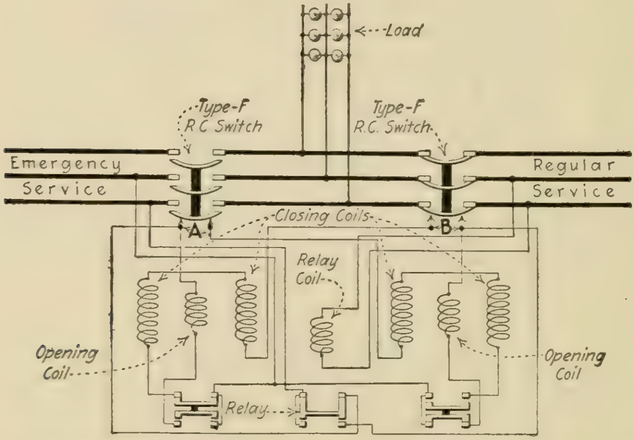


FIG. 419.—Circuit diagram of *Diamond "H"* automatic throw-over switch, showing condition of circuits when the load is receiving current from the regular service.

336. Some Of The Various Methods And Devices Which May Be Used To Control A Remote-controlled Switch are suggested in Fig. 420. The load circuit which is served may be either a motor, *M*, or lamps, *L*. The energy for the control or operating circuit may be supplied either by: (1) *The line, A, which serves the load.* (2) *Storage battery, B.* (3) *Generator or exciter, C.* The operating circuit may be controlled by: (1) *One or more two-circuit momentary-contact switches, S.* (2) *No-voltage release, V.* (3) *Overload release, O.* (4) *Thermostatic regulator, T.* (5) *Time switch, D.* (6) *Pressure regulator, P.* (7) *Float- or tank-switch, F.* When a device other than a momentary-contact switch is to be used to control a remote-controlled switch, the remote-controlled switch should be held closed mechanically, and should be of a type (Secs.

320 and 325) wherein the control current is interrupted by the remote-controlled-switch mechanism.

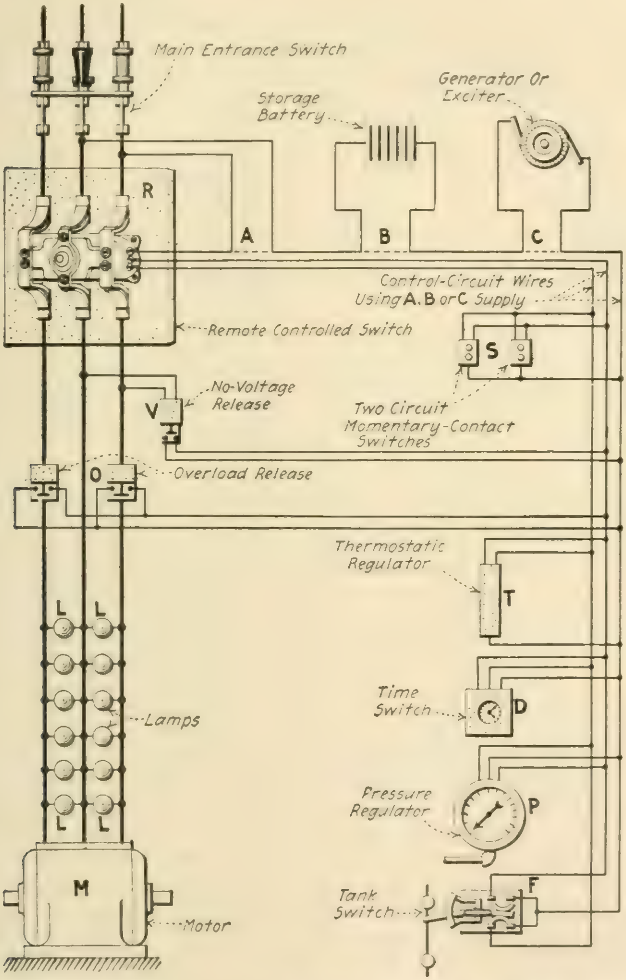


FIG. 420.—Showing general features and various methods and types of control which may be applied to remote-controlled switches. (*Hart Mfg. Co.*)

337. The Control Circuit Of A Remote-controlled Switch Should Be Protected By Fuses. To comply strictly with the CODE requirements (Sec. 169), the control wires (Fig. 421)

should be fused at both *A* and *B*. However, remote-controlled switches for three-wire single-phase lighting service which embody a construction similar to that indicated in Fig. 422 require only one fuse in the control circuit. That is, the wire (*W*, Fig. 422) from the terminal which is connected to the ends of both coils, is connected to the permanently-grounded

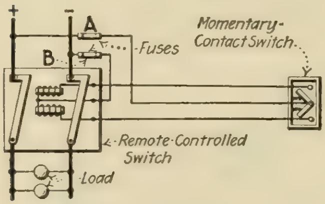


FIG. 421.—Showing method of fusing the control circuit of a remote-controlled switch to comply strictly with CODE requirements.

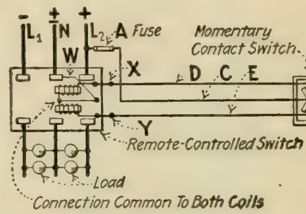


FIG. 422.—Showing a method of fusing the control circuit of a remote-controlled switch which may be permissible for a three-wire single-phase circuit.

neutral. This wire and the high-resistance coils are completely enclosed, and are mounted on the slate base of the switch. Wire *C* is protected against grounds by fuse *A*. If wires *D* or *E* become grounded, no current could flow except when the momentary-contact switch was closed, and they (wires *D* and *E*) would then be protected by fuse *A*. The only possibility which would permit the continued flow of a heavy short-circuit current would be for one of the outside wires, L_1 or L_2, to accidentally contact with wire *W* or with some part of the coil winding. The probability that this would ever happen is exceedingly remote. And if it should occur, the small wires which carry the short circuit current are enclosed and are mounted on a slate base. Consequently, only the switch would be injured, and no fire hazard would be incurred. The local wiring-inspection bureau should be consulted concerning its rules for the fusing of control circuits prior to

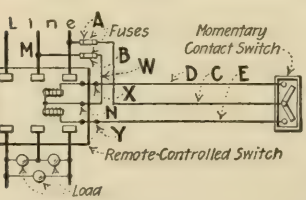


FIG. 423.—Showing proper method of fusing the control circuit of a remote-controlled switch for a three-wire three-phase circuit.

their installation. Local rules might require a fuse at X and Y in Fig. 422.

NOTE.—THE CONTROL CIRCUIT OF A REMOTE-CONTROLLED SWITCH WHICH IS TO BE USED FOR CONTROLLING A THREE-WIRE THREE-PHASE CIRCUIT SHOULD BE PROVIDED WITH AT LEAST TWO FUSES as indicated in Fig. 423. If fuse B is omitted, a ground on D or E might permit a current-flow which would be sufficiently large to incur a fire hazard. If the wiring MN (Fig. 423) is wholly within the switch, some inspection bureaus may require a fuse at X and one at Y.

338. A Remote-controlled Switch Should Be Protected By Fuses in the same manner as is a manually-operated knife-switch. That is, the first fuse back of the switch toward the source of energy should have a rating not greater than the rated current-carrying capacity of the switch. See Div. 3 for CODE requirements relating to fuses and cut-outs.

339. The Comparative Annual Costs Of The Two Systems Under The Given Conditions Should Determine Whether A Remote-control Or A Direct-control Lighting System Should Be Used. In general, the elements which determine these factors are: (1) *The relative locations of the service entrance, the load center of the lamps, and the control locations.* (2) *The number of branch circuits which may be controlled from one location.* (3) *The number of control locations which is wanted.* These elements are discussed in subsequent sections.

NOTE.—THE ANNUAL COST OF EITHER A DIRECT- OR A REMOTE-CONTROL SYSTEM will be the sum of the *fixed costs* per year and the *operating costs* per year. The fixed costs per year include: (1) *Insurance.* (2) *Taxes.* (3) *Interest.* (4) *Depreciation.* The operating costs per year include: (1) *Maintenance.* (2) *Attendance.* (3) *Energy loss.* The costs of maintenance and attendance will usually be about equal for either a direct- or a remote-control system. The annual fixed costs will be determined by the first cost, which will in turn be determined by the allowable energy-loss cost. For example, assume that with a remote-control system, the first cost is higher than it is with a direct-control system. But with the direct-control system, the annual energy-loss cost is higher than it is with a remote-control system. Now, additional copper may be purchased for the direct-control until the annual energy-loss costs of the two systems will be equal. However, this would increase the first cost of the direct-control system, which would correspondingly increase the annual fixed cost of that system. Therefore, the minimum total

annual cost of each of the two systems should be determined. Then, by comparison of the minimum costs of each, the system which incurs the least annual cost should be selected. (See explanation and examples of the application of Kelvin's law in the author's American Electricians' Handbook. See also following example.)

Example.—A current of 30 amp. is required for lighting the room of Fig. 424. The energy is supplied by a 110/220-volt, grounded-neutral, three-wire, single-phase system. The service entrance is located at *E*, the control location must be at *C*, and the distribution panel is located in the center of the room at *P*. The dimensions are as shown in the illustration. Which would provide the more economical installation, a direct control or a remote control lighting system? All wiring is to be installed in conduit.

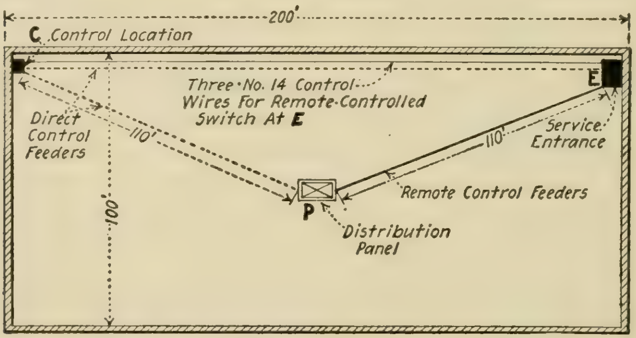


Fig. 424.—Illustrating method of determining the minimum total annual costs of a direct-control and a remote-control lighting system.

Solution.—In the solution of such a problem certain values must be known or assumed, such as energy, labor, wire, conduit and switch costs. The solution which is presented below (scheduled in Table 340) and the values which are therein assumed are only intended to illustrate a method which may be followed in determining the most economical system. It is not intended to prove or disprove either system. Also, the assumed values must not be taken as applying to any particular installation.

The general method of solution is to determine by computation which system is the least expensive—which has the least annual cost. Due to the fact that the total annual cost of either system varies for different conductor sizes, it is necessary to figure, for each of the two systems, this cost for several sizes of wire—all as shown in Table 340 and explained further on. As indicated in Column 4, Table 340, $47.68 is the minimum total annual cost which will be incurred by a direct-control system; this minimum annual cost results from the use of a No. 1 wire. As indicated in column 12, $27.64 is the minimum total annual cost which will be incurred by a remote-control system. Since the remote-control system

involves the smaller annual cost of the two systems, it would be the more economical and hence should be selected. The method of determining these annual costs is outlined below.

The two propositions to be considered are (1) *The direct-control system.* (2) *The remote-control system.* If a direct-control system is used, three feeder wires and conduit for same must be run (Fig. 424) from E to C, and from C to P. There will also be required at the control location, C, an externally-operated, steel-box-enclosed, three-pole, non-fused, 30-amp. knife-switch. If a remote-control system is used, the following material will be required: Three feeder wires and conduit for same from E to P. One three-pole 30-amp. remote-controlled switch at E. Three No. 14. control wires and conduit for same from E to C and one two-circuit momentary-contact switch at C. The method of determining the minimum total annual cost of each system for a certain wire size will now be given.

The assumptions which must be made for either the direct- or the remote-control system are as follows: Assume that the maximum allowable voltage drop between E and P (Fig. 424) is 2 per cent. Then, *the maximum voltage drop between E and P* $= 220 \times 0.02 = 4.4$ *volts.* By For. (35), p. 166, 2d Edition, American Electricians' Handbook, *cir. mils* $= 22 \times I \times L \div V$, wherein: *Circular mils* is area of the conductor in circular mils. I = current in amperes. L = length, in feet, one way or single distance of the circuit. V = drop, in volts in the circuit. For a direct-control system (Fig. 434), $L = EC + CP = 200 + 110 = 310$ *ft.* $I = 30$ *amp.*, and by solution above, $V = 4.4$ *volts.* Therefore, *the minimum area of the wire in circular mils which will carry* 30 *amp. a distance of* 310 *ft. with a voltage drop of* 4.4 *volts* $= 22 \times 30 \times 310 \div 4.4 = 46{,}500$ *cir. mils.* According to Table 170, the minimum size wire corresponding to 46,500 cir. mils. which will give a pressure drop not exceeding 4.4 volts will be a No. 3 B. & S. gage. Any wire larger than No. 3 may from an electrical standpoint, be used; the problem is to determine what size wire is most economical. According to the Code (Table 170) a No. 8 wire could be used to carry the 30-amp. current. However, this would entail an excessive voltage drop.

To illustrate the method of determining the total annual cost of a direct-control system for any given wire size, the following is worked out for a No. 2, B. & S. gage, wire. Assume that the knife switch located at C costs \$15.00. Three wires from E to C to P (Fig. 424) would require: $3 \times 310 = 930$ *ft.* of wire. At \$101.00 per thousand feet of No. 2 wire, 930 ft. would cost $101 \times 930 \div 1{,}000 = \$94.00$. Three No. 2 wires require (Table 176) a 1½-in. conduit. According to Table 173, p. 546, American Electricians' Handbook, 100 ft. of 1½-in. conduit costs \$27.50. Therefore, 310 *ft. costs:* $310 \times 27.50 \div 100 = \$85.00$. According to Fig. 261, p. 639, and Table 356, p. 344 of the American Electricians' Handbook, the cost of roughing in and of pulling three No. 2 wires in 310 ft. of 1½-in. conduit is about \$59.00. Therefore, *the total first cost of a direct-control system* (Fig. 424) $= 15 + 94 + 85 + 59 = \$253.00$.

Assuming that the interest rate is 5 per cent.; depreciation, 4 per cent.; taxes and insurance, 1 per cent.; $5 + 4 + 1 = 10$, or *the annual fixed charges* = 10 *per cent.* of $253 = 0.10 \times 253 = \$25.30$ (see entries in Table 340).

The energy-loss cost is computed as follows: The power-loss in any conductor is: $P = I^2R$, wherein: P = power-loss in watts. I = current in amperes. R = resistance of conductor in ohms. For this direct-control installation (Fig. 424), $I = 30$ amp. and since it is assumed that the grounded neutral carries no current, there will be (2×310) 620 ft. of No. 2 wire which has a resistance of 0.16 ohms per 1,000 ft. Consequently $R = 620 \times 0.16 \div 1{,}000 = 0.099$ ohms. Then, $P = 30 \times 30 \times 0.099 = 89.2$ *watts* which is the power-loss in the conductors. Assuming that the lamps are lighted 10 hr. per day for 300 days per year, *the total number of hours per year which the lamps are lighted* = $300 \times 10 = 3{,}000$ *hr.* Hence, *the annual energy loss in kilowatt-hours* = $3{,}000 \times 89.2 \div 1{,}000 = 268$ kw.-hr. Assuming that the energy costs 8 cts. per kw.-hr., *the annual energy-loss cost* = $268 \times 0.08 = \$21.44$, which value is accordingly entered in Table 340 as shown.

Assume that the cost of maintenance and attendance is $3.00 per year.

Then *the total annual cost of a direct-control system when using No.* 2 *wire* (Column 3, Table 340) = $25.30 + 21.44 + 3.00 = \$49.74$. The values for the other wire sizes for a direct-control system in Table 340 are computed in a similar manner.

The method of determining the total annual cost of a remote-control system (Fig. 424) for any given wire size is illustrated by the following: The same formulas and tables are used and the same general assumptions are made as above. *The minimum area of the wire in circular mils which will carry* 30 *amp. a distance of* 110 *ft. with a voltage drop of* 4.4 *volts* = $22 \times I \times L \div V = 22 \times 30 \times 110 \div 4.4 = 16{,}500$ *cir. mils*, or a No. 8 is the smallest size wire which can be used.

The following example for a No. 8 *wire* (*Column* 9, *Table* 340) *illustrates the method to be used in determining the total annual cost for any wire size for a remote control system.* Assume that the remote-controlled switch and the momentary-contact switch cost $52.00. *Then* ($3 \times 110$) 330 *ft. of No.* 8 *wire from E* to *P at* $17.00 *per thousand feet costs:* $17 \times 330 \div 1{,}000$ = *about* $6.00. And, ($3 \times 200$) 600 *ft. of No.* 14 *wire from E* to *C at* $7.00 *per thousand feet costs:* $7 \times 600 \div 1{,}000$ = *about* $4.00. Hence, *the wire cost* = $6 + 4 = \$10.00$. The *three No.* 8 *wires require* 110 *ft. of* 1-*in. conduit, which at* $17.00 *per hundred feet costs:* $17 \times 110 \div 100$ = *about* $19.00. *The three No.* 14 *wires require* 200 *ft. of* ½-*in. conduit, which at* $8.50 *per hundred feet cost:* $8.50 \times 200 \div 100 = \$17.00$. Hence, *the conduit cost is:* $19 + 17 = \$36.00$. The installation of the conduit will cost about $34.00. Therefore, *the total first cost of a remote-control system using No.* 8 *feeder wires* = $52 + 10 + 36 + 34 = \$132.00$, as is entered in Table 340. Whereupon, *the annual fixed charges* = $132 \times 0.10 = \$13.20$. The *energy-loss cost* = $3{,}000 \times I^2 \times R \times 0.08 \div 1{,}000 = 3{,}000 \times 30 \times 30 \times 0.14 \times 0.08$ = *about* $30.40. Assume that the

cost of maintenance and attendance is \$3.00 per year. Then, *the total annual cost of a remote-control system* (Fig. 424) *when using No.* 8 *wire is:* $13.20 + 30.40 + 3.00 = \$46.60$.

To determine which is the most economical system, first select the size of the wire for the direct-control system which involves the least annual cost for that system; this, in this example, see Table 340, is No. 1 wire, total annual cost \$47.68. Then, select the size of the wire for the remote-control system which involves the least annual cost for that system; this, in this example, see Table 340, is No. 00 wire, total annual cost \$27.64. Then that system of the two selected as above which involves the smaller total annual cost should be used; obviously, in this example, the remote-control system using No. 00 wire with a total annual cost of \$27.64 is the most economical.

340. Table Showing Comparison Of Annual Charges On Direct-control And Remote-control Wiring Systems. See Fig. 424 for diagram. Energy costs 8¢. per kw.-hr. Distances are as shown in Fig. 424. Labor at $7.00 per day.

Elements		Propositions											
		Direct control						Remote control					
		No. 2 wire	No. 1 wire	No. 0 wire	No. 00 wire	No. 000 wire	No. 0000 wire	No. 8 wire	No. 1 wire	No. 0 wire	No. 00 wire	No. 000 wire	No. 0000 wire
First cost in dollars	Switch	15	**15**	15	15	15	15	52	52	52	**52**	52	52
	Wire	94	**112**	125	134	161	192	10	45	50	**52**	62	73
	Conduit	85	**85**	115	115	115	181	36	57	57	**57**	57	80
	Installation	59	**66**	76	78	79	99	34	46	47	**47**	48	54
	Total first cost	253	278	331	342	370	487	132	200	206	**208**	219	259
Fixed charges in dollars	Interest = 5 %, Depreciation = 4 %, Taxes and insurance = 1 % } = 10 %	25.30	**27.80**	33.10	34.20	37.00	48.70	13.20	20.00	20.60	**20.80**	21.90	25.90
Operating charges in dollars	Energy-loss cost	21.44	**16.88**	13.36	10.64	8.40	6.64	30.40	5.92	4.80	**3.84**	2.88	2.40
	Maintenance and attendance	3.00	**3.00**	3.00	3.00	3.00	3.00	3.00	3.00	3.00	**3.00**	3.00	3.00
Total annual cost in dollars		49.74	**47.68**	49.46	47.84	48.40	58.34	46.60	28.92	28.40	**27.64**	27.78	31.30

341. Where The Load Center, The Service Entrance And The Control Location Must Be Separated By A Considerable Distance, A Wire-saving May Be Effected By The Use Of Remote-controlled Switches as shown in Figs. 425 and 426. The control location, *A*, the service entrance, *B*, and the load center, *C*, have the same relative locations in Figs. 425

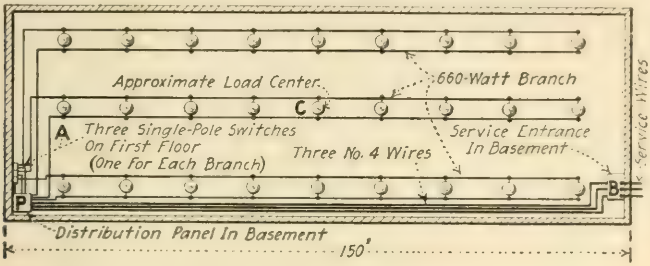


FIG. 425.—Direct control system.

and 426. It is assumed that *A* and *B* must be at the locations shown. In Fig. 425, the control, *A*, of each of the 660-watt branches of the load-circuit is provided by a single-pole switch. Therefore, the distribution panel, *P*, is located as near to *A* as is feasible. Then, three large wires (each of which should, for this installation, be about No. 4, B. & S. gage)

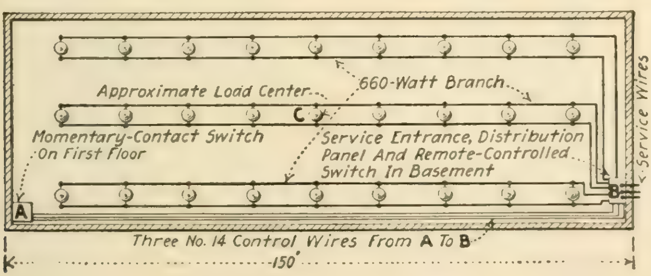


FIG. 426.—Remote-control system.

would be required between *P* and *B*. By using a remote-controlled switch to control the three branch circuits, as in Fig. 426, three No. 14 wires will be required between *A* and *B*. Therefore, if the distance from the control location *A* to the service entrance *B* is, say, 150 ft., the wire-saving which will be effected by the remote-control system over the direct-control

system will be the difference between 450 ft. of No. 4 wire and 450 ft. of No. 14 wire, which is about 50 lb. of copper.

Note.—If It Was Desired To Arrange The Control Of Fig. 426 So That Each Branch Could Be Lighted Or Extinguished Separately, then three remote-controlled switches would be required at *B*, three two-circuit momentary-contact switches would be required at *A*, and seven (see Fig. 408) No. 14 control wires would be required between *A* and *B*, if a common-return was used. If a common-return wire was not used, then nine control wires would be required between *A* and *B*. In such cases the remote-control system might not be justified.

342. A Remote-control System May Be Used For Those Installations Where It Is Desired That The Lamps On A Large Number Of 660-watt Branch Circuits Be Simultane-

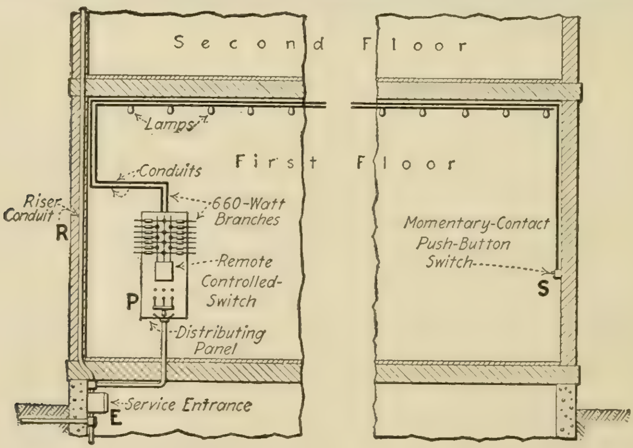


Fig. 427.—Remote-control installation for controlling all circuits on one floor (This is especially applicable where the service entrance, *E*, and the riser, *R*, are at one end of the building and where it is desired that the control location, *S*, be near the elevator shaft or stairway at the other end of the building.)

ously Lighted And Extinguished (Fig. 427). This system is especially desirable where the control location, *S*, which is provided by the momentary-contact switch is at a great distance (Fig. 427) from the distribution panel (Fig. 428). Even if the control-location (*S*, Fig. 427) was near the distributing panel, *P*, a remote-control system might be preferable to a knife-switch direct-control system because of the following reasons: If a knife switch which carries a large current is

frequently operated by inexperienced persons, severe arcs may be drawn which will damage the switch and may, if the switch is not of the externally-operated type (Fig. 140), injure the operator.

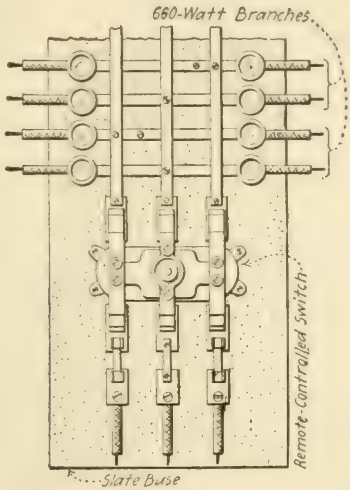


FIG. 428.—A three-wire to two-wire distribution panel controlled by a remote-controlled switch. (*Hart Mfg. Co.*)

343. A Remote-control System Will Frequently Provide An Economical Installation For Multi-location Control Of A Large Number Of Lamps. The distribution panel may be located in the most desirable place with reference to available-space and load center considerations. The control locations are provided by two-circuit momentary-contact switches which are wired according to Fig. 406 or Fig. 408.

EXAMPLE.—In Fig. 429, the distribution panel, *D*, for the *auditorium lights* and for the stage lights of a small *moving-picture theatre* is located on the stage. Four momentary-contact switches are used to control the lights: Two for the stage lights and two for the auditorium lights. One of the switches, *W*, for controlling the stage lights and one, *X*, for controlling the auditorium lights are located in the lobby. The other two switches, *Y* and *Z*, are located in the picture-machine booth. Hence, both the stage and auditorium lights may be controlled from either the picture-machine booth, or from the lobby in the front of the house (see also Div. 9).

Example.—In Fig. 430, the lamps of a large ceiling fixture, such as that frequently used in churches, are controlled by a remote-controlled switch. Where sufficient space is available to provide access thereto, the

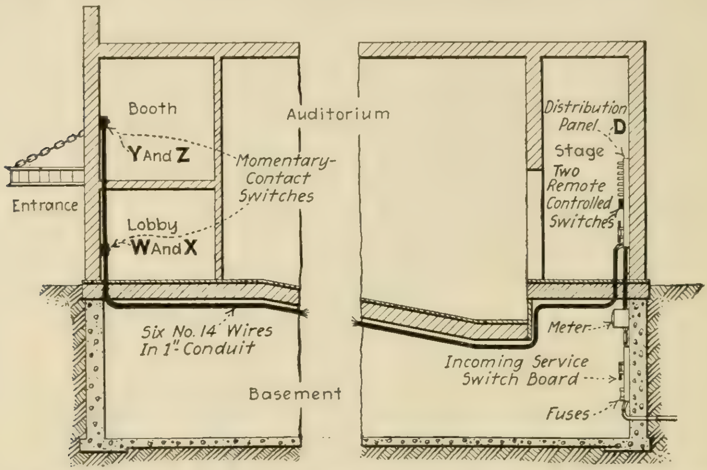


Fig. 429.—Remote-control system for controlling the stage and auditorium lights of a small moving picture house.

remote-controlled-switch distribution panel may be installed between the ceiling and the roof in close proximity to the dome fixture. As many control locations as desired may be provided by momentary-contact

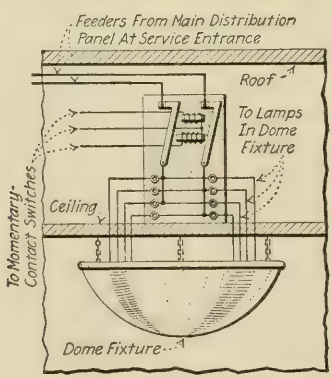


Fig. 430.—Remote-controlled switch, installed between ceiling and roof, to control lamps in a large dome fixture.

switches connected as shown in either Fig. 406 or 408. This method tends to decrease the cost of wiring because it shortens the branch circuits.

344. Electrically-held-closed, Single-pole, Remote-controlled Switches May Be Used To Control Lamps In Moving-picture Studios. (*Electrical South*, July 1921; p. 24.) Each of the remote-controlled switches (R, Fig. 431) which are located overhead, control an arc-lamp circuit. The single-pole switches, S and M, and the three-way switches, T, are mounted on a portable base and connected as shown in Fig. 431. Mounting the remote-controlled switches overhead prevents the heavy cables from being scattered about the floor. A constant source of danger to the studio workmen is thereby removed. As explained below, the portable switch-box, B,

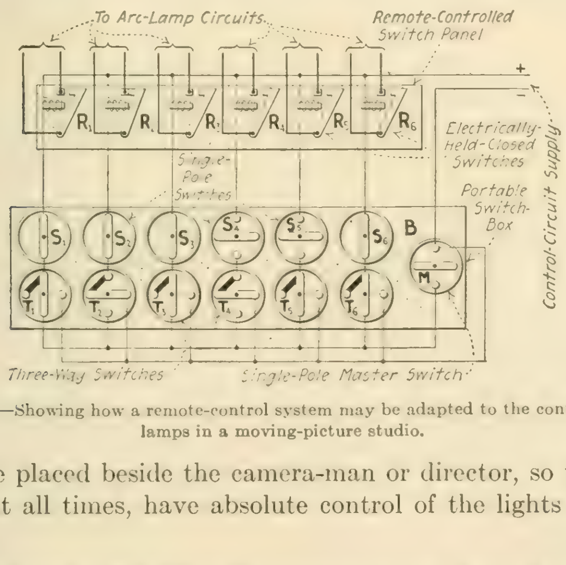


FIG. 431.—Showing how a remote-control system may be adapted to the control of arc lamps in a moving-picture studio.

may be placed beside the camera-man or director, so that he may, at all times, have absolute control of the lights on the scene.

EXPLANATION.—The usual practice of controlling the lights for a scene was to station a man at the studio switchboard, who, upon a given signal, closed the switches to the lamp circuits to be lighted. These signals frequently miscarried so that when the actor entered the room and apparently operated a wall switch, the room did not light. Then the scene had to be retaken. With the remote-control system this error will not occur.

Assume that a certain scene opens with a "dark room" effect. Sufficient light for this effect is provided by the arc lamps which are controlled by R_2 (Fig. 431). The director sets switches S_2 and T_2 (Fig. 431) in the positions shown. This closes R_2 and lights the proper lamps. A little later the actor is to enter the darkened room and grope about until he

locates the wall switch which is supposed to control the electrolier fixture of the room. The director sets S_1, T_1, S_3, T_3, S_6 and T_6 in the positions shown. As the actor finds the wall switch in the darkened room, the director closes the master switch M. This simultaneously closes the remote-controlled switches, R_1, R_3, and R_6. The illusion of the actor lighting the room is maintained as follows: R_1 controls a baby arc which is concealed in the lamp sockets of the room chandelier. R_2 controls several flood lights which illminate the entire room. R_6 controls a number of spot lights which bring out the features and expression of the actor. Since S_4 and S_5 are left open, the lamps which are controlled by R_4 and R_5 are not lighted.

345. The Master Switch For Controlling A Master Circuit In A Residence Or Other Building May Be A Remote-controlled Switch (Fig. 432). The same general rules as outlined

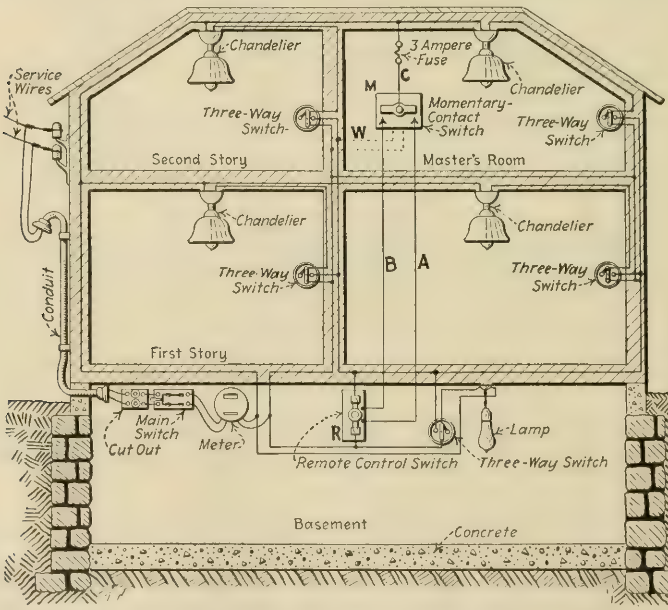


FIG. 432.—A remote-controlled switch used to control the master circuit in a small residence.

in Div. 6 in regard to the interconnection of branches and the number of poles required for the master switch must be observed. As explained below, such use of a remote-controlled switch will not ordinarily be justified in medium- and small-sized residences. However, in large buildings which have

several branch circuits, the installation of a remote-controlled master switch may (Sec. 346) be advisable.

Explanation.—Number 14 wire will ordinarily be large enough for the branch circuits and for the master wires in small- and medium-sized residences. Also, No. 14 wires are required for the control of a remote-controlled switch. Therefore, for such installations, the use of a remote-controlled switch does not generally effect a wire-saving. In Fig. 432, assume that the remote-controlled switch, R and the momentary-contact switch M and the control-circuit wires, A, B, and C, are removed. Control of the master circuit may then be provided as follows: (1) *Install a single-pole snap-switch at M.* (2) *Connect M into the circuit with No. 14 wires as indicated by the dotted lines at W.* Thus, by using a direct-control system (Div. 6) for the master circuit instead of a remote-control system, a considerable saving is effected.

346. A Remote-controlled Master Switch For Master Circuits Of Large Residences Or Other Buildings is shown in Fig. 433. Switches of this type are made with from 8

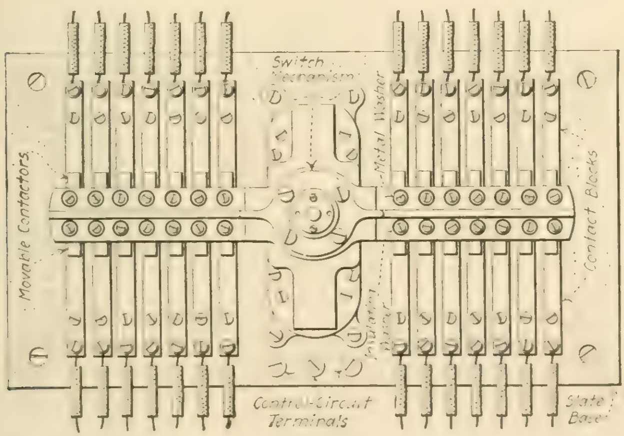


Fig. 433.—Remote-controlled, multi-circuit switch for the control of a master circuit. (*Hart Mfg. Co.*)

to 20 poles. The wiring diagram of an 18-pole switch used to master 18 branch circuits is shown in Fig. 434. As explained in Sec. 291 in connection with Fig. 337, single-location control of the lamp-groups may, if there is only one lamp-group on each branch circuit, be provided by single-pole switches. The use of such a remote-controlled master switch

may effect a large saving over direct-controlled master switches in those installations where several branch circuits are to be

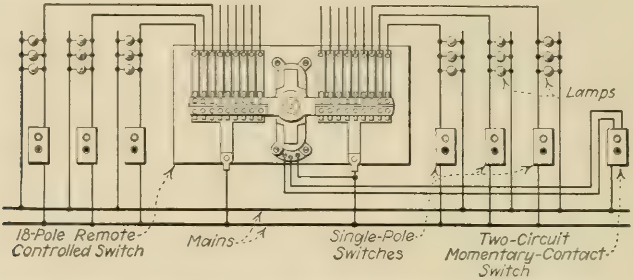


FIG. 434.—Wiring diagram of a multi-pole remote-controlled master switch. (Since each branch circuit has connected to it only one lamp-group, a single-pole switch may be used for single-location control of each lamp-group.)

mastered and where several master-switch-control locations are desired.

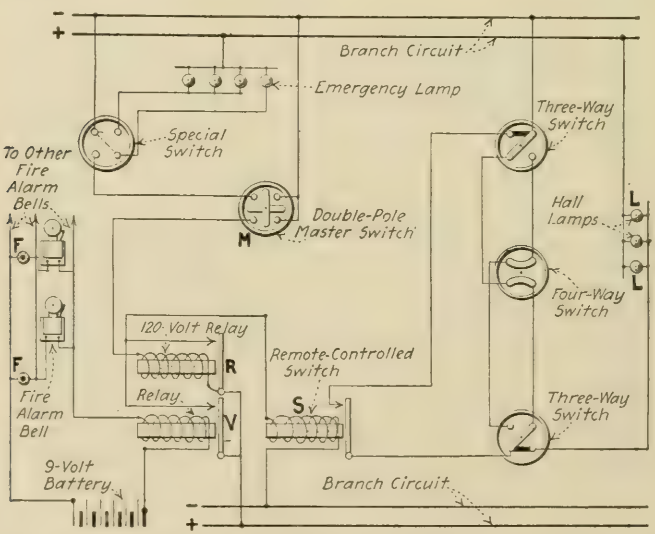


FIG. 435.—Circuit diagram of a combined remote- and direct-control system for a master circuit arranged to operate in conjunction with a fire-alarm system.

NOTE.—A CIRCUIT DIAGRAM OF A COMBINED DIRECT- AND REMOTE-CONTROL SYSTEM FOR THE MASTER CIRCUITS OF A LARGE BUILDING is shown in Fig. 435. One pole of the double-pole master switch, M, provides direct-control of a master circuit. By arranging this master

circuit as explained in Sec. 291, several lamps may be directly mastered thereby. The other pole of M controls the circuit of the 120-volt relay, R. Closing R causes the electrically-held-closed remote-controlled switch, S, to close, thus lighting the three-location-controlled hall-and-stairway lamps, L. If the residence is a three-story building, and has a three-location-controlled lamp-group for each floor, a three-pole, electrically-held-closed switch may be used at S and each pole connected to each lamp-group. The building may also be provided with a *fire alarm* which is so arranged that sounding the fire alarm (Fig. 435) will light the hall-and-stairway lamps of each floor. If any single-pole switch, F, is closed to ring the fire-alarm bells, relay, V, then operates and closes the control circuit of S, and all of the hall lamps are lighted.

347. Table Showing List Price And Standard Ratings Of One Type Of Sundh Remote-controlled Switches (*Bulletin* 7,200, p. 2, *Sundh Electric Co.*). In January, 1922, a maximum discount of 33⅓ per cent. applied to the following quotations:

Volts 115–230 Direct Current or 110–220–440 A.C. 60 Cycles or less

Ampere	1 Pole	2 Pole	3 Pole	4 Pole
30	....	$ 35.00	$ 40.00	$ 54.00
60	....	45.00	50.00	81.00
100	....	75.00	90.00	162.00
200	....	112.00	131.00	225.00
300	$135.00	144.00	162.00	288.00
400	153.00	166.00	216.00	333.00
500	194.00	207.00	261.00	423.00
600	212.00	243.00	306.00	
800	248.00	275.00	350.00	
1,000	293.00	311.00	387.00	
1,500	338.00			
2,000	450.00	Prices on other sizes upon request		
2,500	562.00			

When Ordering: For Direct Current, give capacity of switch, number of poles and voltage of circuit. For Alternating Current, give capacity of switch, number of poles, and exact voltage and frequency of circuit.

NOTE.—Although the above table is not intended to contain the prices or ratings of all remote-controlled switches, the values contained therein are probably, in general, typical for other makes and types.

348. A Method Of Controlling Signs By Remote-controlled Switches is shown in Fig. 436. The *Topeka (Kan.) Edison Company* operated a number of flat-rate signs. These were switched "on" at dusk and "off" at 10 o'clock, except on Saturday night, when they were burned until 11:30 p. m. When controlled and switched by hand, as formerly, the company received the usual complaints because one sign was turned on or off before another as the patrolman progressed on his rounds. This previously-unavoidable dissatisfaction ceased with the installation of the remote-control system

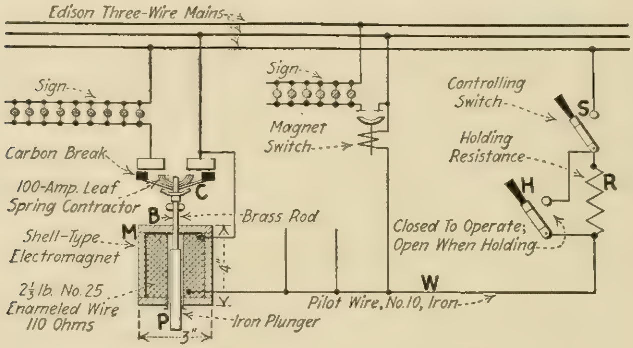


FIG. 436.—Remote-controlled switches controlling flat-rate signs.

which is shown and the wage of the patrolman, $20 per month, was saved by this switching of all the signs from a central point. A remote-controlled switch was installed at each sign.

EXPLANATION.—Shell-type electromagnets, *M*, were used in the remote-control switches. The outer dimensions of the iron magnetic-return casing were 4 in. long by 3 in. in diameter. The iron plunger, *P*, had 1-in. travel in the 1-in. brass tube in which it slides. Two and one-third pounds of No. 25 black enameled magnet wire were used in each coil. A brass rod, *B*, connected the plunger with the leaf-spring contactors, *C*, which were supplemented by carbon-break blocks which "take" any arcs that form on breaking the circuit. *J. E. Gossett*, electrical foreman, who laid out the scheme, estimated the cost of these magnet switches to be about $6 each.

Extending through the business district is a No. 10 iron wire, *W*, which is used as the pilot circuit and is tapped in multiple to the remote-control magnet windings. Each magnet coil has a resistance of about 110 ohms and at 110 volts takes 1 amp. which closes the contact effectively. A current of less than 1 amp. will hold the plunger in the closed position.

Hence, at the control location there is a resistor *R* of a predetermined resistance (110 ohms) which can, by opening switch *H*, be inserted in the pilot circuit after the remote-controlled switches have been closed. This reduces the current per coil to 0.5 amp., which is ample to hold the contacts in position. To light the signs, the controlling switch, *S*, is closed (the resistance switch, *H*, having already been closed); thereby current is permitted to flow through the remote-controlled switches. Switch *H* is then opened, thereby inserting resistance *R* into the circuit to cut the holding current down to normal value, so that the magnets will not heat. Fifteen large signs were operated by the Topeka pilot-wire circuit, which was nearly a mile in length.

349. A Method Which Has Been Employed For The Remote Control Of An Alternating-current Series Incandescent Lamp Circuit is shown diagrammatically in Fig. 437. *The Worcester (Mass.) Electric Light Company* installed a

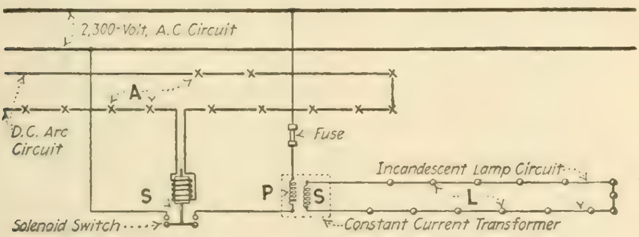


FIG. 437.—Remote control of a series incandescent lamp circuit.

number of trial 4 amp., 75 watt alternating-current tungsten series incandescent lamp circuits, *L*, early in 1912, for the street illumination of outlying districts. To economize in the feeder investment for this work, *Fred H. Smith*, superintendent of the company, devised the plan which is shown by which energy for the operation of each circuit is derived from the regular 2,300-volt, single-phase commercial feeders of the plant.

EXPLANATION.—Each circuit of series incandescent lamps contains from 50 to 75 lamps looped through a suburban zone. Each circuit is fed from a constant-current transformer, *PS*, located in a pole box in the immediate neighborhood of the lamp district. The constant-current transformer is connected across the 2,300-volt line. One side of the primary of *PS* is fused and the other side connected through a solenoid switch, *S*. The actuating coil of the solenoid switch, *S*, is in series with one of the company's direct-current series street arc-lighting circuits which passes the location of the transformer.

The series incandescent lamp circuit is switched on automatically at the time the direct-current arc service is switched into operation: The closing of the d.c. arc circuit at the station lights the arc lamps, *A*, and simultaneously permits current to pass through the solenoid switch coil in the pole box. This closes the contacts of the local constant-current transformer primary, *P*, and lights the series incandescent lamps, *L*. In order to keep the alternating-current incandescent circuit constantly in service, regardless of the current fluctuations and regulation of the direct-current arc-lamp circuit, a pole piece is installed in the core of the solenoid switch. This pole piece is so designed that the plunger of the switch is drawn firmly against the pole piece at the instant current first passes through the arc circuit and coil of switch *S*. Even if no direct-current passes through the coil of *S*, the residual magnetism of this pole piece is sufficient to hold the plunger up against the pole piece. In the morning when the direct-current arc circuit is cut off, the incandescent service remains on until an operator at the distributing substation permits alternating current to flow through the d.c. arc circuit. This demagnetizes the solenoid core which permits the plunger to drop and open the series incandescent circuit. The solenoid switch is of the oil type.

Fourteen alternating-current incandescent circuits arranged as described were in operation at Worcester. The loads on the different circuits vary from 4 kw. to 10 kw. The effect upon the 2,300-volt lines has been negligible. By the use of the automatic switch, *S*, which is built for high-potential operation, no patrolman is required to switch the series incandescent lamps on and off. The arrangement has saved money in underground conduits, ducts and feeders, besides rendering unnecessary a switchboard at the main distributing center.

350. Remote Control Of Street Lamps Which Are Fed From An Edison System is illustrated in Fig. 438. This arrangement was used in the business section of *Dayton, Ohio*, which was lighted by 360, 340-watt tungsten clusters, divided into seven sections, three of which are shown. Each section was fed at a convenient point from the 220-volt Edison three-wire mains (*M*, Fig. 438) of the *Dayton Lighting Company*. Formerly controlled by hand from street switches, this lighting when arranged as shown can all be manipulated practically simultaneously from the station switchboard, *AB*. The magnet-switch scheme which is shown requires considerably less wiring than is necessary for the usual distribution or for pilot-wire controls. The scheme was developed by *O. H. Hutchings*, general superintendent of the company.

Explanation.—Closing one of the control switches, *A* or *B*, (Fig. 438) energizes the magnet contactor, C_1, of a nearby section. As this section

lights up, it in turn energizes the contactors, C_2, of section No. 2. The action is similarly repeated throughout the system, until the lighting of the last section is indicated by the pilot lamps, L, on the switchboard. One switch B, thus controls the four lower 60-watt post lamps which are operated till midnight; the other switch, A, governs the single 100-watt post lamps which are operated all night. Although this is not shown in the sketch, each section is balanced on the three-wire system, double-pole, switches being used instead of the single contacts, C, which are indicated in Fig. 104. Individual sets of these 100-amp. *General Electric* carbon break contacts are mounted, with the section fuses and meter, in a 30-in.

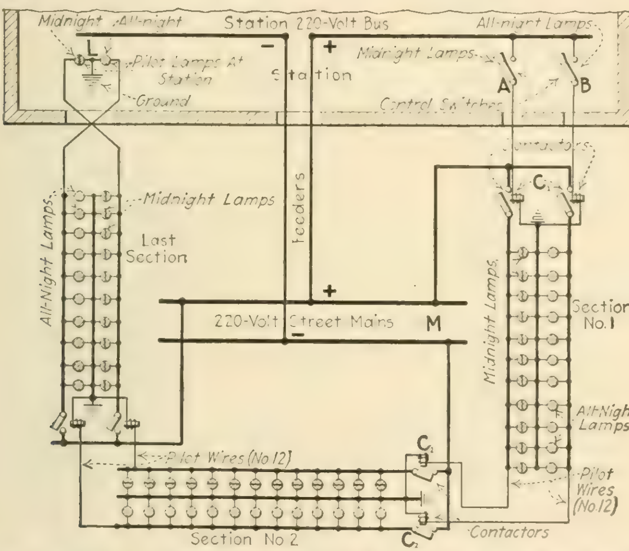


Fig. 438.—Remote control of street lamps which are fed from an Edison three-wire system.

by 34-in. gasketed man-hole box which is installed at the feeding point of each section. The meters are read monthly and the switches are inspected and cleaned at this time. Each magnet winding takes about 0.3 amp. at 110 volts in its holding position, and the contacts carry 58 amp. to 90 amp.

From the instant that the control switch is closed to that at which the corresponding pilot lamp flashes, barely one second elapses. Hence this is the time required for the impulse to traverse the seven switches and a total distance of 10,500 ft. Half of this path is in the No. 12 pilot-wire circuit. The average length of the pilot circuit is 785 ft. The system cost $120 per switch station to install, exclusive of meters. It saved about one-half hour's daily operation, due to irregular lighting, or about

60 kw.-hr. per day, in addition to labor. Half a mile from the nearest post-lighting circuit, the Dayton company also lights a bridge with alternating-current multiple tungsten lamps. The control of these has been effected by extending a pilot circuit and magnet switch from the direct-current curb system, replacing a time switch which was formerly used at the bridge. The cost of operating the curb system was $55 per 340-watt post per year.

351. Another Method Of Remote-control Operation Of Ornamental Street Lighting is illustrated in Fig. 439. The arrangement was used in Peoria, Ill. where 240 five-lamp standards were employed to light the downtown section of the city. The five-lamp standards are fed in groups of six from the

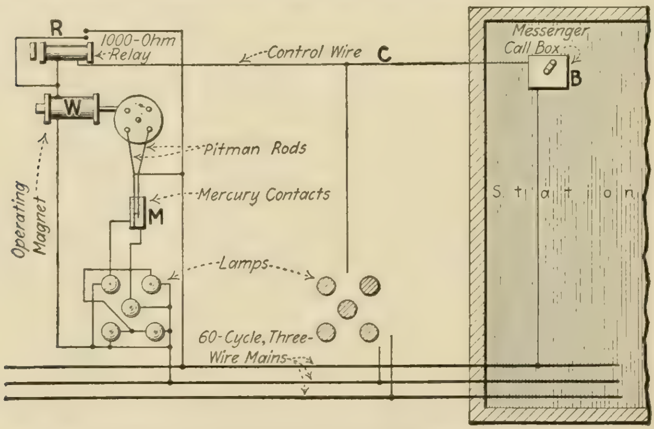


FIG. 439.—Remote control of ornamental street lighting system in Peoria, Ill.

110/220-volt alternating-current three-wire mains. They are switched on and off by means of a remote-control pilot circuit (Fig. 439) which operates relay switches at the feeding points. With a step-by-step mechanism the four 60-watt lamps or the single 100-watt lamps on each 5-lamp standard may be turned positively on and off, independently of the others. Only a single control wire is used.

EXPLANATION.—At each feeding point for a six-post group, a relay switch (Fig. 439) is installed in a post base. The switch includes a 1,000-ohm telephone relay, *R*, bridged between the control wire, *C*, and the system neutral, and the 50-ohm switch magnet, *M*, the winding, *W*, of which is energized through the relay contact. This operating magnet, *W*, works against the switch shaft, rotating it 90 deg. each time the mag-

net is energized. Pitman rods which extend from this shaft, control contacts dipping into the two mercury cups of the switch. One cup is for the top-lamp circuit and the other is for the four lower lamps. The crank pins for these rods are also quartered 90 deg., as Fig. 105 shows, so that in succession both contacts may be down, or one up and one down,

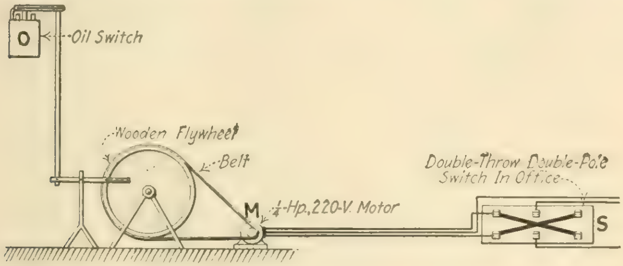


FIG. 440.—Oil switch which is remotely controlled by a small three-phase motor.

or both up. This series of positions is passed through in the course of one rotation, lighting first the lower lamps, then the top lamps, then extinguishing the lower lamps and finally extinguishing the top lamps.

Some difficulty was at first experienced in timing the impulses to operate all the relays and switches positively, but the messenger call-box mechanism, *B*, which was finally adopted, solved this problem. The current impulses in the control wire, *C*, are, by *B*, each maintained at about 15-sec. duration with a 5-sec. interval between each impulse. Another slight source of trouble was due to the sensitiveness of the relays as they were first installed. A heavy blow on the lamp post, such as that caused by a wagon riding over the curb, would cause a momentary closure of the contact, throwing the control circuit of that post out of step. But these minor difficulties were speedily cleared. Each switch, before being installed, received a test of 500 operations without a single failure. Each switch mechanism is inclosed in a 6-in. by 10-in. iron box, 2 in. deep, which has fiber entry bushings for the wires. Each outfit cost about $12, as made in a local shop. The No. 10 control wire, *C*, which operates the forty switches has a total length of about 3 miles. Each relay takes about 0.1 amp. and the operating magnets 2 amp. momentarily. *C. A. Rich*, foreman of the underground department for the *Peoria Gas & Electric Company*, devised the installation described.

FIG. 441.—Self-restoring push-button door snap switch. (*Bryant Electric Co.*)

NOTE.—THE REMOTE CONTROL OF EITHER PRIMARY OR SECONDARY CIRCUITS MAY BE PROVIDED BY MEANS OF A SMALL MOTOR (By D. E.

King) as shown in Fig. 440. The three-phase motor, M, is fed from a No. 14 wire at a potential of 220 volts, the distance from the office to the switch being a quarter of a mile. The oil switch, O, connects the 2,300-

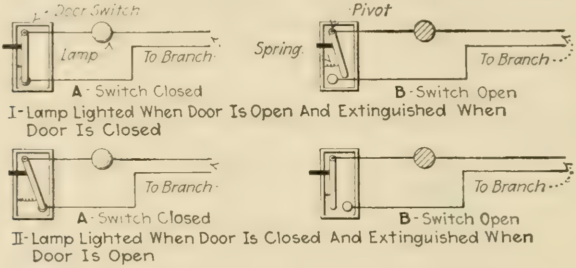


FIG. 442.—Door-switch circuit-diagrams.

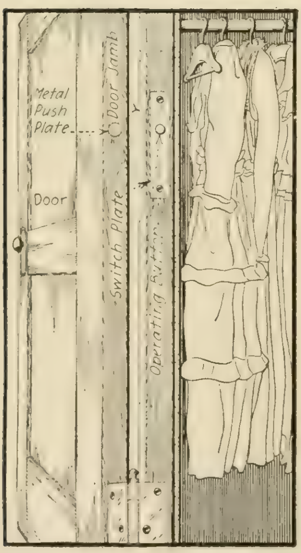


FIG. 443.—Door switch installed in the door jamb of a closet so that the circuit is closed when the door is opened.

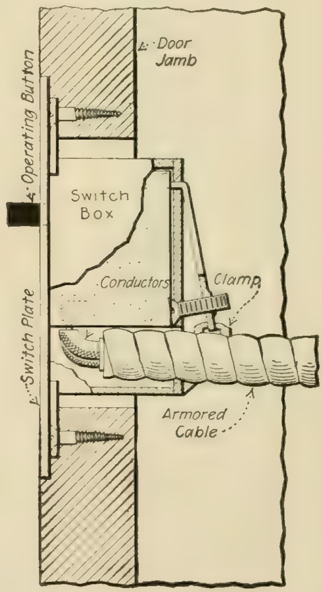


FIG. 444.—Showing a door switch installed in a door jamb and the method of securing an armored cable to the switch box. (*Catalog Nos.* 7240 *and* 7241, *Cutler-Hammer Mfg. Co.*)

volt primaries with two constant-current transformers, used for series *street lighting.* To throw the circuit on or off, reverse the direction of rotation of the motor. To effect this a two-pole, double-throw switch S

is used. The center leg of the motor is always in circuit and when the switch is thrown in one position two of the phases are reversed. In the other position the connections are normal.

352. A Door Switch May Be Installed In The Door Jamb So That Opening And Closing The Door Operates The Switch. Switches of this type (Fig. 441) are made (Sec. 95) so that the circuit (Fig. 442) may either be opened or closed by closing the

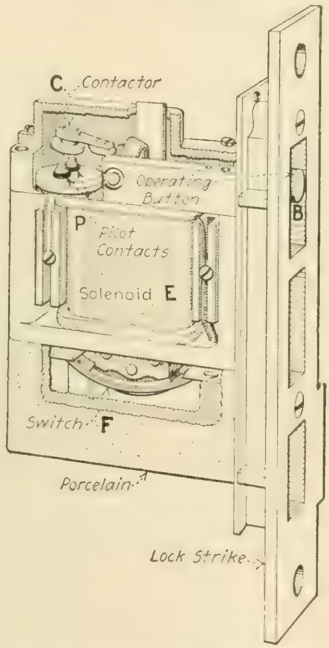


Fig. 445.—Solenoid door-bolt switch for automatic control of lights in hotel rooms. This switch sets in the door jamb. (*Hart Mfg. Co.*)

door (Fig. 443). Door switches which are so designed that the lamp is lighted when the door is open and extinguished when the door is closed are suitable for installations in clothes closets, linen closets, entrance halls, vaults, and the like. Door switches which light the lamp when the door is closed and extinguish it when the door is open are used principally in telephone booths, toilets, and the like, where one would naturally close the door after entering. A method of fastening armored cable to a door switch is shown in Fig. 444.

353. The Solenoid Door-bolt Switch (Figs. 445, 445*A*, 445*B*, and 446) is used principally in hotel guest-rooms to effect a current-saving. It is so operated by the bolt in the door lock that when the guest leaves the room and locks the door any lamps which he may have left burning therein will be extinguished. A separate bolt is used to lock the door from the inside. This inside locking bolt does not operate the switch. One manufacturer of such a switch estimates that the cost of the current

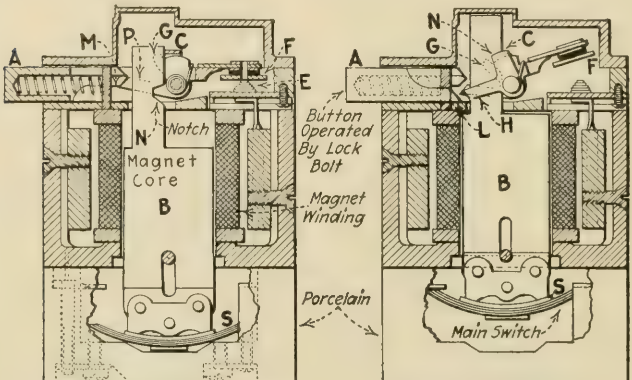


Fig. 445*A*.—Mechanism of *Hart Mfg. Co's. Type D* magnetic door-bolt switch. (A sectional elevation is shown at *I*, and a partial sectional elevation at *II*. As shown at *I*, the door has just been unlocked from the outside, permitting contactor plate *F* to drop down and touch the two contact points, *E*, only one of which is shown. This completes the circuit through the magnet, which immediately raises the core *B* to that position shown at *II*, thus closing the main switch *S*. When S closes, the lug *C* is pulled into the notch *N* by a spring. When *C* is pulled into *N*, *C* engages with another lug *G*, and raises *F* off the two contacts *E*. Thus, the main switch is closed and the electromagnet circuit is opened, thereby permitting the lamps to be controlled from the inside of the room by the room switch. When the occupant leaves the room and locks the door from the outside, the button *A* is pushed in. This causes the cam surface, *L*, to strike and raise the prong *H*. Thereby *C* is disengaged from *N* and the main switch *S* drops open. Also when *A* is pushed in and the main switch is opened, the under side of *M* (in *I*) holds prong *P* down so that *F* cannot touch E. Thus the electromagnet carries no current while the switch is open or closed. The only time the electromagnet carries current is for an instant after the door is unlocked from the outside.)

which will be saved by its use will pay for the switch in about 18 months. That the switch will operate to save current is based on the assumption that a hotel guest is more likely to lock the door when he leaves the room than he is to turn off the

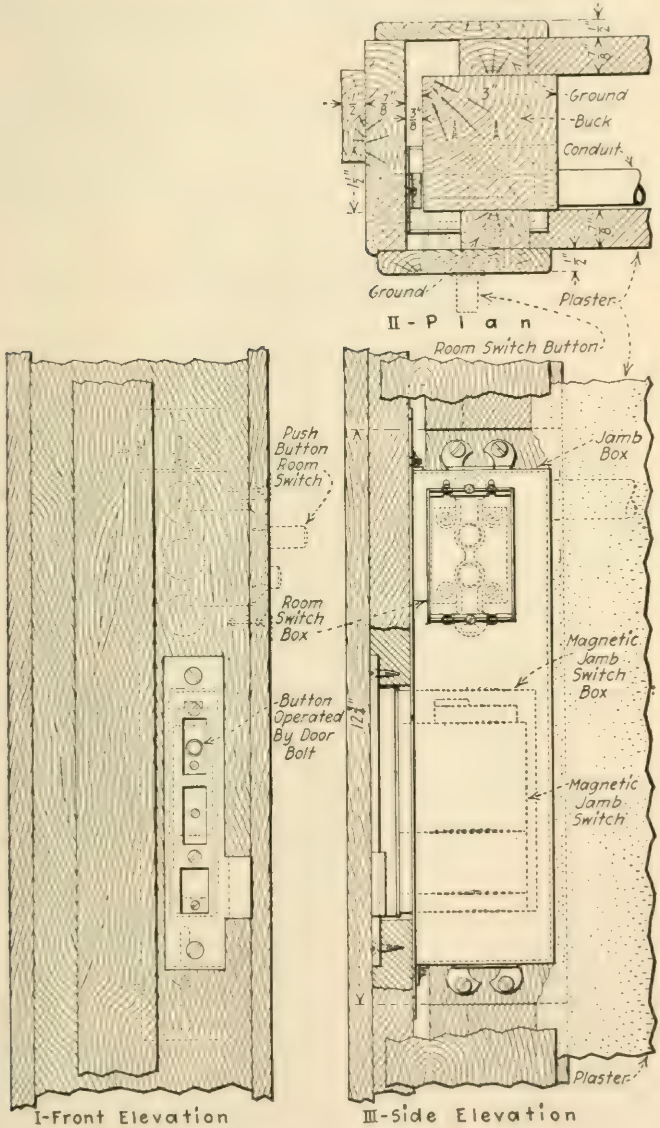


FIG. 445B.—Installation of door-bolt switch. (*Hart Mfg. Co.*)

lights. The operation of the switch is explained below. The usual rating of door-bolt switches is 3 amp. at 250 volts, or 6 amp. at 125 volts.

EXPLANATION.—When the door is locked from the outside, the lock bolt, L, passes into the strike and operates the switch button (B, Figs. 445, 446, and 447) so that the contactor (C, Figs. 445 and 447) is raised off of the pilot contacts (P, Figs. 445 and 447). Therefore, when the door is not locked from the outside—occupant is within the room—

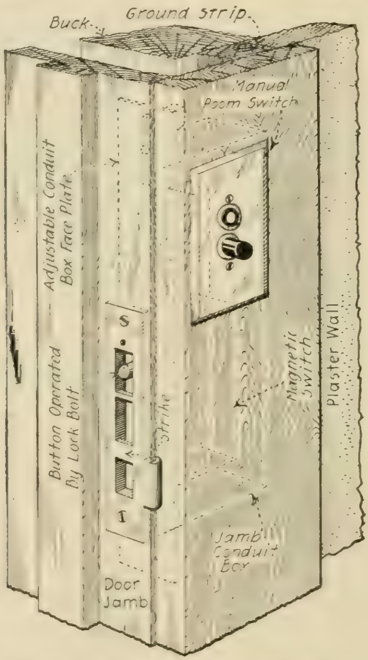


FIG. 446.—Solenoid door-bolt switch installed in door jamb. (*Hart Mfg. Co.*)

the solenoid (E, Figs. 445 and 447) will be energized by a very small current-flow from X to Y. This raises and closes the single-pole switch, F, which is connected in series with one side of the line. Then, the lighting and extinguishing of the center lamps may be controlled by operating the single-pole room switch (G, Fig. 447). The bracket and toilet lamps may then be controlled by their respective key sockets.

When the occupant leaves the room and locks the door, the electrical connection between the pilot contacts, P, is as explained above, broken. Solenoid E is thereby de-energized and the switch F drops downward to the open position. This opens one side of the line. Consequently any lamps within the room which may have been left lighted are extin-

guished when the door is locked. Then when the door is unlocked from the outside, those lamps which were left on when the occupant departed will be automatically relighted.

NOTE.—THE MAXIMUM INSTANTANEOUS CURRENT TAKEN BY THE SOLENOID of the Hart switch is 1.2 amp. These values are for 110-volt switches.

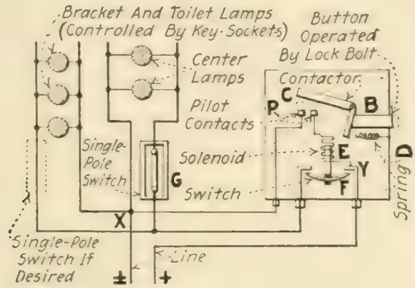


FIG. 447.—Explaining operation of a solenoid door-bolt switch.

354. Various Circuit Diagrams For Solenoid Door-bolt Switches are shown in Figs. 447, 448, 449, and 450. An installation connected according to any of these diagrams will, as explained in preceding Sec. 353, operate to extinguish all of the

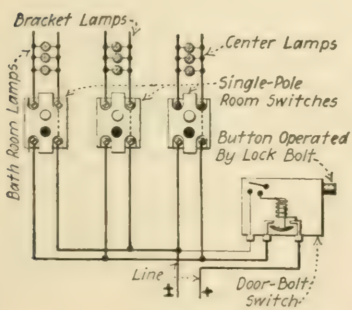


FIG. 448.

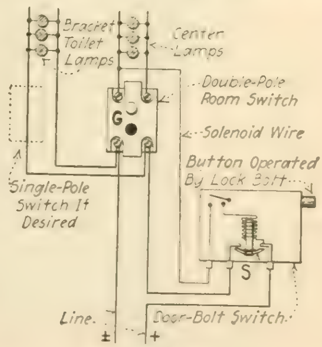


FIG. 449.

FIG. 448.—Circuit diagram of solenoid door-bolt switch for controlling room lights with two or more single-pole room switches. (*Hart Mfg. Co.*)

FIG. 449.—Circuit diagram of solenoid door-bolt switch for controlling all lights with one room switch. (When *G* is open, *F* is open. When *G* is closed *S* will be closed if the door is not locked from the outside. When the door is locked from the outside, *F* is open. *Hart Mfg. Co.*)

lamps within the room when the door is locked from the outside. In Fig. 449, a double-pole room switch, *G*, is used. The

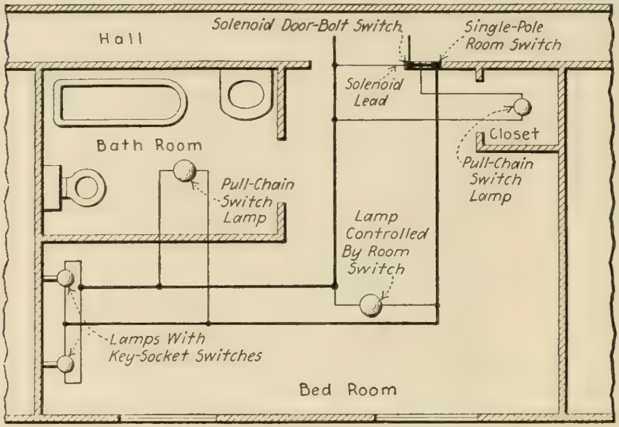


FIG. 450.—Hotel-room solenoid door-bolt switch installation. This corresponds to the circuit diagram of Fig. 447. A double-pole room switch connected as indicated in Fig. 449 is preferable.

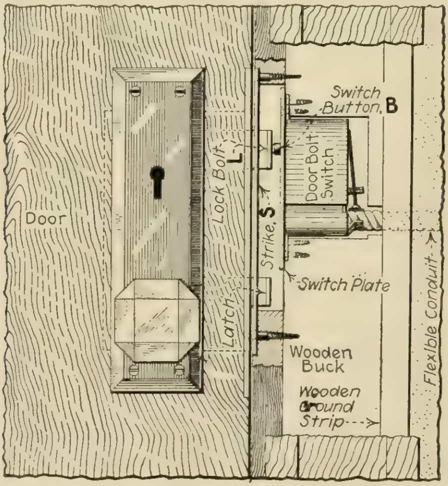


FIG. 451.—Showing a door-bolt switch installed in the door jamb with wood screws. They can also be mounted on the strike by using spacers and machine screws furnished with the switch or directly on the back of a box strike without the spacers. Two holes are tapped in the switch plate for the screws. The drilling of the strike is as shown. (*Cutler-Hammer Mfg. Co., List No.* 7242.)

solenoid wire is connected to a point which is behind G. Therefore, when G is open, no current can flow through the solenoid. Thus, all of the lamps within the room may be controlled by G, because when G is opened, the solenoid is

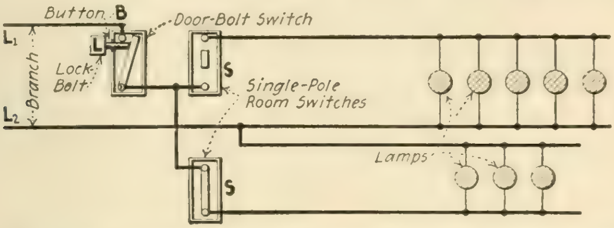


FIG. 452.—Circuit diagram of single-pole door-bolt switch which is directly operated by the lock bolt. Two single-pole room switches, S, control the lamps when the door is unlocked from the outside.

de-energized, and switch S opens. For this reason, the bracket and toilet lamps cannot be lighted except when G is closed. The method shown in Fig. 448 will usually be more

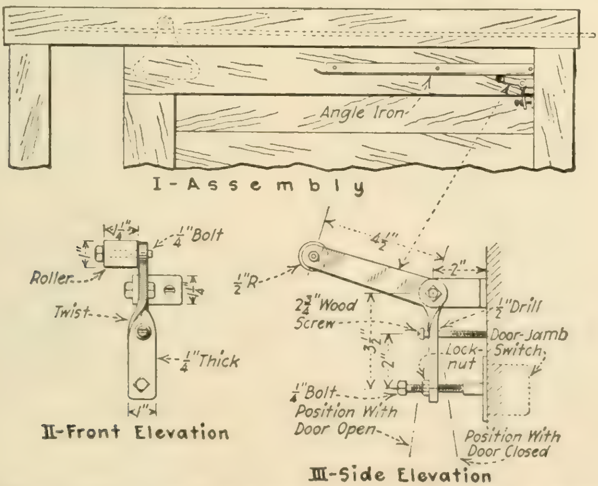


FIG. 452A.—Method of installing a door-bolt switch which is to be operated by a sliding door. (Lamps within the storeroom are lighted when the roller runs off of the angle iron as the door is opened. The lamps will be extinguished when the door is closed, even though it is not closed tightly. In some construction it may be necessary to provide a channel or groove in the wall for the angle iron.)

economical from a current-saving standpoint than that shown in Fig. 447 or 449.

NOTE.—A DOOR-BOLT SWITCH WHICH IS DIRECTLY OPERATED BY THE LOCK BOLT is shown in Fig. 451. This mechanism consists of a single-pole switch, the construction of which is similar to the door switch described in Sec. 95. When the door is locked from the outside, the lock bolt, *L*, (Fig. 451) strikes the switch button, *B*, and opens the switch. When the door is unlocked from the outside the switch is closed by a spring (Sec. 95). This door-bolt switch is connected into one side of the line as shown in Fig. 452. One or more single-pole room switches (*S*, Fig. 452) control the lamps within the room when the door is unlocked from the outside. A method of installing such a switch for a sliding door is illustrated in Fig. 452A. The function of the directly operated door-bolt switch is the same as that of the solenoid door-bolt switch (Sec. 353).

355. A Time Switch is a switch which is so operated by a clock mechanism that the switch will be automatically opened

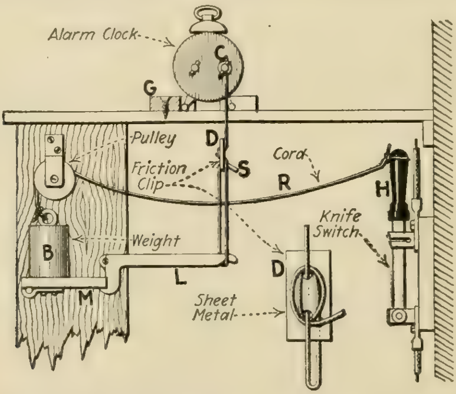


FIG. 453.—An improvised alarm-clock time switch. This arrangement would probably not be approved by an insurance inspection bureau. (The clock is anchored to the shelf by notched blocks, *G*. A string *S*, is so wound around the alarm-winding stem *C*, that when the alarm goes off the string will be pulled. Pulling the string releases weight, *B*, by means of lever, *L*, and hinged shelf, *M*. The weight in falling pulls switch handle, *H*, by means of cord, *R*. The clip, *D*, is used in taking up the slack in the string.)

or closed by the clock at a predetermined time. A simple time switch may be constructed by rigging an ordinary knife switch to an alarm clock (Fig. 453), so that when the alarm mechanism is tripped the switch will be operated. However, the commercial time switches usually comprise a high-grade clock mechanism, a mechanical switch propelling device, and a switch, all of which are compacted into a small metallic protecting case. The types of switches which are usually employed in connection with time-switch mechanisms of the

different makes are shown in Table 369. The clock-work spring and the propelling-mechanism spring have to be wound by hand, except where an electric winding device is provided as in Fig. 465. Rewinding is usually required every 8 days. Various commercial time-switch mechanisms are described in the following sections.

356. A Time Switch Can Generally Be Economically Used To Control A Circuit Which It Is Desirable To Open Or Close At Definite Times, and where there is no reliable person present at those times to do this work. Specific examples of time-switch applications are outlined hereinafter.

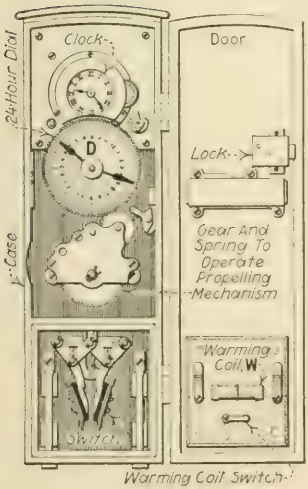


FIG. 454.—Double-pole, single-throw *Anderson* time switch. (*Type F. Albert & J. M. Anderson Mfg. Co.*)

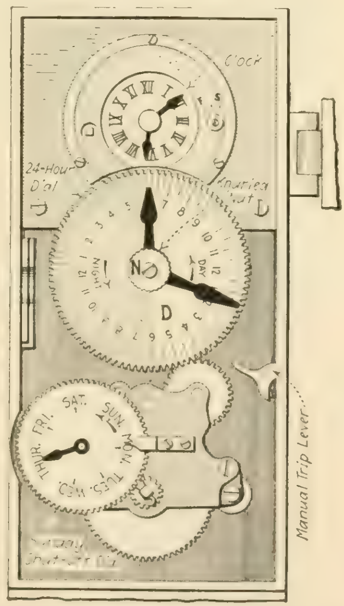


FIG. 455.—Clock and associated parts of an *Anderson* time switch showing Sunday shut-off dial.

357. The Anderson Time Switch (Fig. 454) consists of three principal units: (1) *The clock and its associated parts*, Fig. 455, which trip the propelling mechanism. (2) *The propelling mechanism*, Fig. 456, which operates the switch. (3) *The*

switch, Fig. 457, which opens and closes the circuit. The operation of each of these units is explained below.

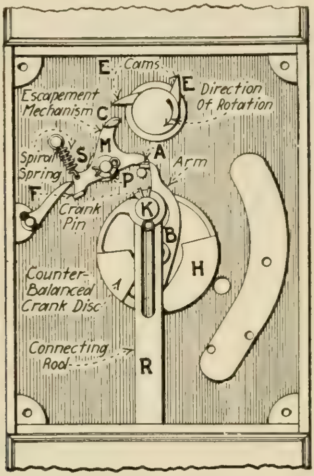


Fig. 456.—Propelling mechanism of an *Anderson* time switch. (Switch in open position.)

Explanation.—The 24-hr. dial (D, Fig. 455) which is geared to and rotated by the clockwork mechanism, makes one complete revolution

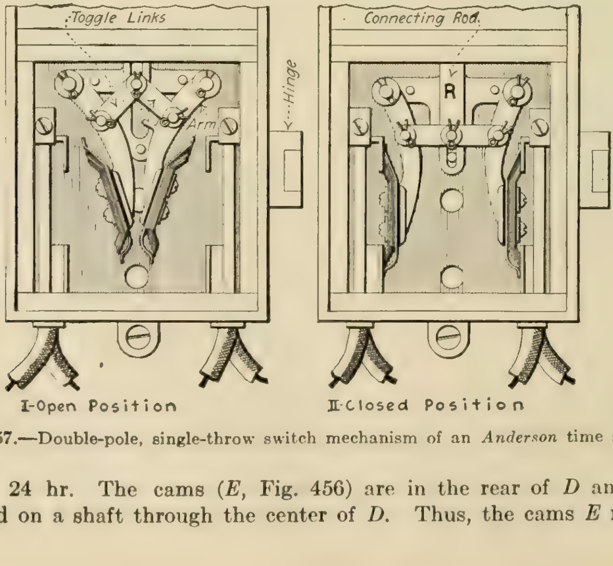


Fig. 457.—Double-pole, single-throw switch mechanism of an *Anderson* time switch.

every 24 hr. The cams (E, Fig. 456) are in the rear of D and are carried on a shaft through the center of D. Thus, the cams E rotate

with D. The relative position of these cams is changed by loosening the knurled nut (N, Fig. 455) and setting the hands of the 24-hr. dial with the fingers. Setting these hands according to the figures on D (Fig. 455) determines the time at which the switch will be operated.

The operation of the switch is as follows: Consider one of the cams (E, Fig. 456), which is rotated by the clock mechanism in the direction indicated by the arrow. When the incline of E, (Fig. 458) comes in contact with the projecting lug, C, E will—as it continues to rotate—exert a pressure on C which will cause the escapement mechanism, M, to tilt upward about the pivot, P, until the projection A rises high enough to

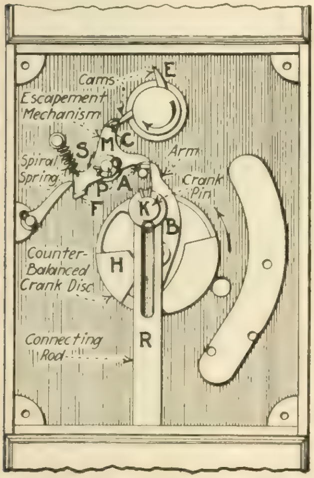


FIG. 458.—Escapement mechanism of an *Anderson* time switch being tilted up by the clock-actuated cam, E.

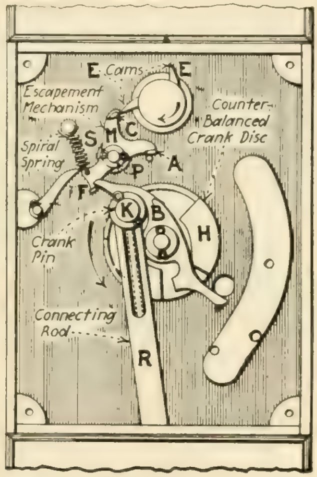


FIG. 459.—Propelling mechanism of an *Anderson* time switch after having made a portion of the one half revolution required for one operation of the switch.

allow the point of arm B to pass under it. This movement, which has tilted A upward, has, at the same time, tilted F downward. Therefore, when the upper end of arm B, which is moved in the direction of the arrow by the spring of the propelling mechanism, is released from A, it will only rotate until it strikes F, as shown in Fig. 459. Shortly afterward, the point of cam E passes by the knife-edge of projection C, thus allowing the spiral spring, S, to pull M back into its original position. This disengages B and F, and the operating spring of the propelling mechanism causes B to rotate. Rotation of B is stopped—after one half revolution—by the other end of B striking against A as shown in Fig. 460. This one-half revolution of B and the crank disc, H, carries the crank-pin, K, to a position (Fig. 460), which is diametrically opposite to that which is shown in Fig. 456. This lowers the connecting rod, R, and

closes the switch as shown in Fig. 457-*II*. When the next cam strikes *C*, (Fig. 460) the cycle which is described above is repeated, and *R* is raised into the position shown in Figs. 456 and 457-*I*. The switch is then open. The manner in which the switch is opened and closed through the toggle-link mechanism may be understood from a consideration of Fig. 457.

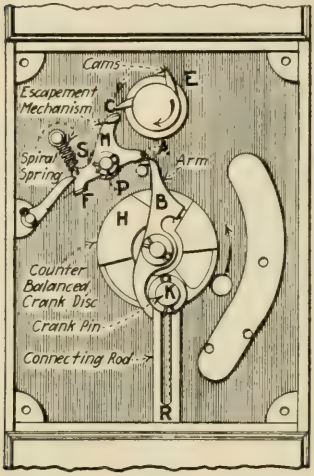


FIG. 460.—Propelling mechanism of an *Anderson* time switch. (Switch in closed position.)

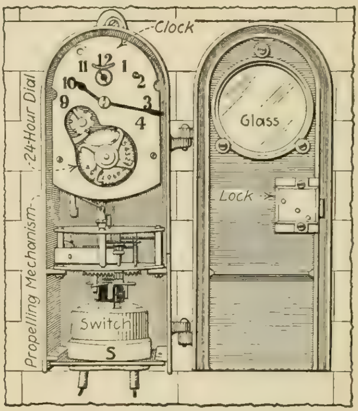


FIG. 461.—*Paragon* time switch. (*Paragon Electric Co.*)

358. The Paragon Time Switch (Fig. 461) consists of three principal parts: (1) *The clock.* (2) *The propelling mechanism.* (3) *The switch.* The type of clock shown has four hands on the 24-hr. dial. This permits of four operations each 24 hr. That is, the switch may be opened twice and closed twice during this period. The maximum capacity of the snap switch, *S*, is 30 amp. If a current larger than 30 amp. is to be controlled by this instrument, a remote-controlled switch is used, and *S* is connected through three No. 14 wires to the opening and closing coils of the remote-controlled switch.

359. In The Mercury Time Switch (Fig. 462), the principal parts of each pole of the double-pole-switch mechanism are a pivoted switch blade (*G*, Fig. 463) and a mercury-cup, *D*, which is filled with mercury. When the switch is closed (Fig. 463-*I*), the current-path is that which is indicated by the

arrows. The switch is held in the closed position by the spiral spring, *S*. If the switch handle (*H* Fig. 463-*I*) is pushed to the right, the spiral spring, *S*, opens the switch by

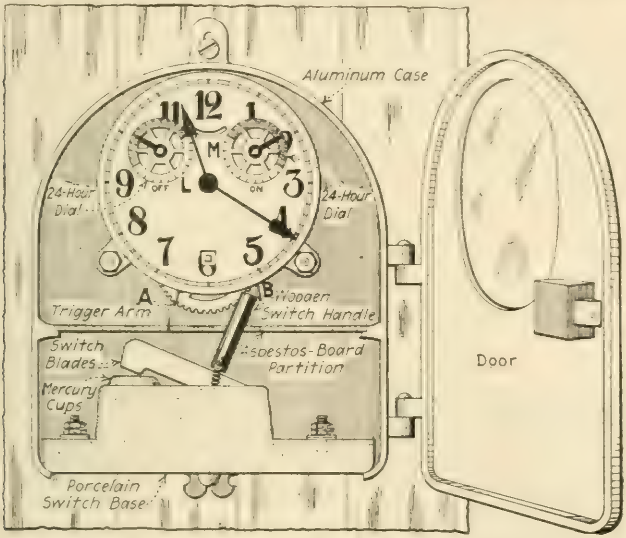


FIG. 462.—*Mercury* time switch. (*Mercury Time Switch Co.*)

raising the blade out of the mercury (Fig. 463-*II*) with almost a snap action. If now *H* is pushed to the left, the switch is closed. In the time switch (Fig. 462), *H* is pushed to the right by a trigger arm *A* and to the left by another trigger arm,

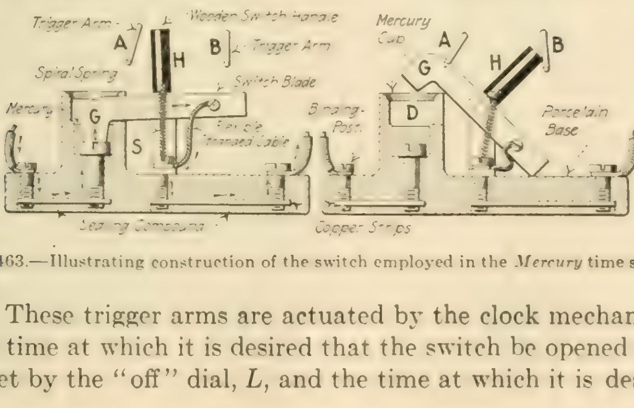


FIG. 463.—Illustrating construction of the switch employed in the *Mercury* time switch.

B. These trigger arms are actuated by the clock mechanism. The time at which it is desired that the switch be opened may be set by the "off" dial, *L*, and the time at which it is desired

that the switch be closed may be set by the "on" dial, M. When the time arrives at which the "off" dial, L, has been set, the trigger arm, A, flips to the right, thus kicking the switch open. When the time arrives at which the "on" dial, M, has been set, trigger arm B flips to the left, thus closing the switch. The apparatus is so constructed that each of the operations (one opening and one closing) described above may be made to occur every 24 hr.

360. Various Devices Which Are Intended To Decrease The Personal Supervision Of Time Switches have been developed by certain manufacturers. The functions of the principal devices of this sort are described in the paragraphs below.

361. A Time Switch May Be So Made That Four Daily Operations Will Occur (Sec. 358). That is, during each 24 hr., it will, say close the switch, then open it, then close it again, and then open it again. *Time switches are also made so that three daily operations will occur.* The Paragon switch (Fig. 461) will operate 4 times daily. The Anderson Company makes switches which will operate respectively 2, 3 or 4 times daily. The Mercury switch operates 2 times daily.

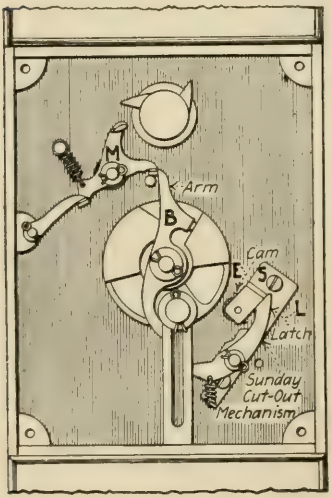


Fig. 464.—Showing the Sunday cut-out mechanism on an *Anderson* time switch. (Every seven days a cam, E, so operates the latch, L, that the arm is prevented from rotating for a period of 24 hr.)

362. The So-called "Sunday" Shut-off Device (Figs. 455 and 464) operates to shut off the operation of the switch for a period of one 24-hr. day in each 7 days. In those localities where it is not deemed necessary to have the show-window or similar lamps lighted on Sunday night, a switch which is equipped with a Sunday shut-off device may be used. Then the lamps will be lighted and extinguished each weekday at the time set on the dial and on Sunday they do not light at all.

363. The So-called "Saturday Night Overtime" Device (*Albert & J. M. Anderson Mfg. Co.*) operates to cause the time switch to automatically interrupt the current later, say 2 hr. later, on any one night out of seven than the time at which it operates on the other nights. That is, the switch may be set to extinguish the lights, say, at 11:00 p.m.

on every night except Saturday, on which night it does not extinguish them until 1:00 a.m. Sunday. Such a device is especially desirable in connection with a time switch for controlling the lights in a show window in the business section of a city.

364. A WARMING COIL ON A TIME SWITCH (*Anderson* and *Paragon*) is used to warm the clock when it is exposed to extremely low temperatures. If the temperature of the clock drops to about 0° F., the oil will thicken and cause the clock either to run slower or to stop altogether. The warming coil is intended to prevent this. The warming-coil circuit on some clocks is provided with a thermostat so that the coil is automatically cut out of circuit in warm weather and cut in again in cold weather. The warming coil on other clocks (*W*, Fig. 454) is provided with a switch whereby the coil is manually connected and disconnected.

365. BY EQUIPPING A TIME CLOCK WITH A SWITCH-LOCK-OUT DEVICE, (*Paragon switch*) the switch-propelling mechanism may be prevented from operating while the clock continues to mark time. This lock-out device is usually manually operated. If it is desired to discontinue the switch operation for one or more days, the switch is locked by this device. Then when the switch is unlocked, the regular cycle of switch operation will be resumed.

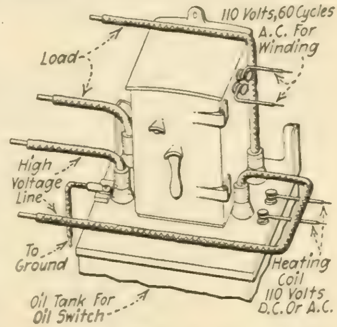


FIG. 465.—Wiring diagram of an electrically-wound, high-voltage, oil-break time switch. (*Type T, Albert & J. M. Anderson Mfg. Co.*)

366. AN ELECTRICALLY-WOUND TIME SWITCH (Fig. 465) is one wherein the propelling-mechanism spring and the clock mainspring are wound automatically by an electric current. Such an appliance is especially advantageous for a time switch which is to be installed in an isolated location, such as an outlying series-arc-lamp sub-station, or on the framework of an electric sign which is on the top of a high building. The only attention, so the manufacturers claim, that will be required by a time switch which is so equipped is to change the setting to correspond with the change of seasons and to oil it about twice a year.

367. A SEASON CHANGING DEVICE ON A TIME SWITCH causes the time at which the switch opens and closes to vary according to the time at which the sun rises and sets. One manufacturer (*A. & J. M. Anderson Mfg. Co.*) of such a device states that when adjustments are made for the latitude where the time switch is to be used, the instrument will follow the sunrise and sunset with a maximum error of about 15 min. from sunrise on Aug. 15 and a similar error of 15 min. from sunset on May 15, but will be practically correct on Dec. 15 and June 15.

That is, assume that the time switch is set at Boston, Mass. on June 15, so that the lamps will be extinguished at 3:05 a.m. and lighted at 8:25 p.m.

(These times are, respectively, about 1 hr. before sunrise and 1 hr. after sunset at Boston, Mass. on June 15.) Then, without further attention to the setting, the instrument will, on Aug. 15, extinguish the lamps at about 3:30 a.m., which is about 1 hr. and 5 min. before sunrise. On the same date the lamps will be lighted at 7:45 p.m., which is about 1 hr. after sunset. On Dec. 15, it will extinguish the lamps at 6:05 a.m. and light them at 5:10 p.m., which times are, respectively, again 1 hr. before sunrise and 1 hr. after sunset, just as the settings were made on June 15.

368. From the explanations in the preceding notes it is evident that certain manufacturers' time switches may be so equipped that they will operate every day in the week, do overtime on Saturday night, rest all day Sunday, warm itself when the weather gets cold, wind itself, and follow the seasonal changes in the time at which the sun rises and sets.

369. Table Showing Classification Of Time Switches As Regularly Manufactured By The Anderson Company According To The Type Of Switch.

Type of break	Type of mechanism	Operation
Air break	Snap switch (Fig. 466)	Electrolier Single-pole, single-throw Double-pole, single-throw Three-pole, single-throw
	Laminated copper brush (Fig. 454)	Single-pole, single-throw Double-pole, single-throw Double-pole, double-throw Three-pole, single-throw
Oil break	Laminated copper brush (Fig. 469)	Double-pole, single-throw Three-pole, single-throw

370. The Applications Of The Switches Of The Different Types Which Are Used In Time Switches are, in general, as noted below.

Note.—Time Switches Which Are Equipped With A Snap Switch are used to control small loads not exceeding 30 amp. at 250 volts, such as small lighting loads and remote-controlled switches. The remote-controlled switch may in turn control a load of any reasonable magnitude. Air-break time switches which have laminated copper brushes are used to control loads from 10 to 250 amp. at not over 250 volts. Oil-break time switches are used for loads up to 50 amp. at from 500 to 6,600 volts.

371. The Cost Of Time Switches varies from about $35.00 up to $450.00, depending upon the type, capacity, and (Sec. 360) appliances. For estimating purposes the following costs may be assumed: A 30-amp. switch costs about $75.00; a 60-amp. switch about $100.00; a 100-amp. switch about $300.00; and a 200-amp. switch about $400.00. The various special appliances which are listed in Secs. 362 to 368 may cost from $5.00 to $50.00 extra.

372. The Circuit-connections For A Time Switch will depend upon the type of the switch which is used. The circuit diagrams given in Divs. 4 and 7 for single-pole, multi-pole or electrolier switch circuits may be followed for connecting time switches of the respective types.

Note.—The Electrolier Switches Which Are Designed For Use In Connection With Time Switches are usually two-circuit, three position (Div. 7) electrolier switches. Such a switch usually requires that the time switch mechanism be provided for three operations daily. That is, one time switch operation per day must be provided for each electrolier switch position. For example see Sec. 375.

373. The Kinds Of Lighting-circuit Installations Which Time Switches Are Frequently Used To Control are: (1) *Signs.* (2) *Show windows.* (3) *Hall-ways of apartment houses.* (4) *Poultry houses.* (5) *Electric railway waiting stations.* (6) *Two-rate meter service installations.* (7) *Street lamps.* Time switches are also frequently used to control the length of time which storage batteries are on charge, to control motors for ventilation and refrigeration, and the like. Since storage battery and motor applications are not within the scope of this book, only those listed above from (1) to (7) inclusive, will be described in the following sections.

374. Time Switches May Be Used To Control The Lighting Of Outdoor Electric Signs, both of the flasher and of the constantly-lighted types. Where a time switch is used to control a flasher sign, it may be so connected that both the lamps and the motor which drives the flasher are controlled by the same switch. Where several bill-boards which are owned by the same company are grouped close together, one time switch may be used to control the lighting of the entire group. Such installations, instead of requiring an attendant to visit them twice daily to turn the lamps on and off, will only require an occasional inspection of the lamps and time

switch. If the time switch mechanism is not electrically wound, it will have to be periodically wound by hand, ordinarily once each week.

375. Time Switches May Be Advantageously Used To Control The Lamps In Show-windows which are not under the care of a night-watchman. Even where there is a community night-watchman whose duty it is to turn the window lamps on and off at given hours, a time switch may pay for itself in a few years by the current saved and by eliminating the night-watchman's fee. Where it is desired that the illumination of a brightly lighted window be decreased during the night, the lamps may be connected to two circuits. Then by controlling these two circuits with a two-circuit, three-position electrolier time switch which operates three times daily, all of the lamps may be automatically turned on at dark. Then, later in the evening when traffic has decreased, a part of the lamps may be extinguished and a part left burning. Finally, just before daybreak, all of the lights may be extinguished. The electrolier switch for such service should provide a "1 & 2—1—Off" control sequence. Figs. 461 and 466 show time switch mechanisms which operate electrolier switches.

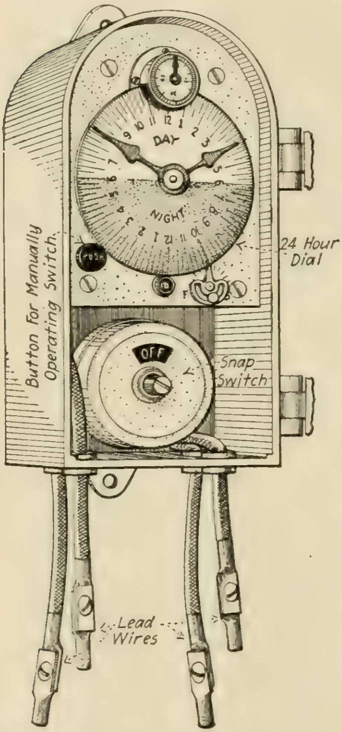


Fig. 466.—*Anderson Type P* time switch.

376. Time Switches May Be Used To Control The Hallway Lights Of Apartment Houses where it is desired to extinguish all of the hall lights at a certain hour. Or they may be employed where it is desired that only a part of the hall lamps be extinguished at a certain hour of the night

and the remainder be left burning until morning. For this latter control the lamps are connected to two different circuits. Then the two circuits are controlled by a two-circuit three-position electrolier time switch which operates three times daily (Sec. 375)

Note.—Time Switches Are Sometimes Used To Control The Lamps In Poultry Houses, thereby increasing the apparent daylight period, and providing a longer working day for the poultry. This is believed by some poultrymen to increase egg production.

Note.—The Lamps In Railway Waiting Stations May Be Controlled By Time Switches so that, at stations where there is no agent or attendant, the lamps will not be left burning during the day time or during the night hours when there are no trains. The type, capacity and connections for the time switch controlling such lamps will be essentially the same as for a manually operated switch for the same service.

377. Two-rate Meter Service May Be Controlled By A Double-pole Double-throw Time Switch (Fig. 467) which has no off position. Central station companies will sometimes sell electrical energy which is used during the light-load period at a lower rate than that which is used during the peak-load period. In such cases, a time switch may be used to transfer the load from one meter to the other at specified times.

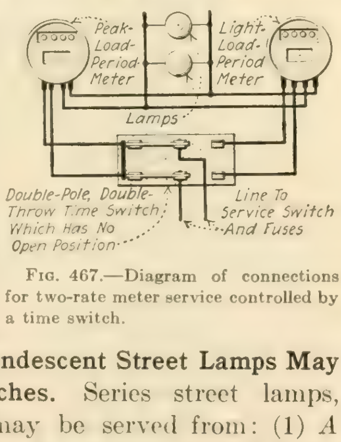


Fig. 467.—Diagram of connections for two-rate meter service controlled by a time switch.

378. The Extinguishing And Lighting Of Series Arc And Incandescent Street Lamps May Be Controlled By Time Switches. Series street lamps, whether arc or incandescent, may be served from: (1) *A constant-current transformer.* (2) *A constant-potential transformer.* (3) *A constant-potential auto-transformer.* (4) *Direct from a constant-potential feeder.* Various methods which are employed and the types of time switches used for controlling each are described in the following sections.

379. A Time Switch Of A Special Type Is Generally Required For The Control Of A Series Lamp Circuit Which Is Fed By A Constant-current Transformer. If the coils of a

constant-current transformer are close together when the lamp load is switched into the circuit, considerable damage to the lamps may result. Consequently, it is necessary that

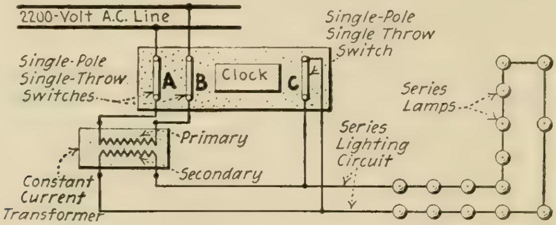


FIG. 468.—Wiring diagram of a time switch which automatically separates the coils of a constant-current transformer before the series lamps are connected into the circuit. (*Type M; A. & J. M. Anderson Mfg. Co.*)

the coils be separated before the lamp load is thrown on the transformer. A time switch which automatically effects this coil-separation before the lamps are lighted, employs three single-pole switches (A, B and C, Fig. 468); the operation is as follows:

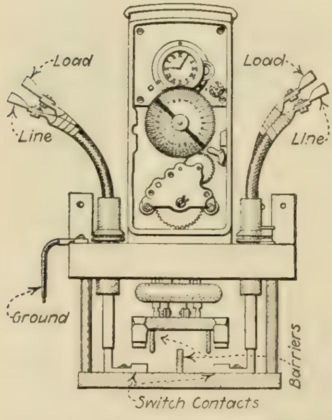


FIG. 469.—Double-pole, single-throw oil-break time switch with oil tank removed. (*A. & J. M. Anderson Mfg. Co.*)

EXPLANATION.—Two of the switches (A and B, 468) are connected into the primary of the transformer. These two switches (A and B) are simultaneously opened and closed by the clock mechanism. The third switch, C, is connected across the terminals of the secondary circuit. Switch C closes simultaneously with switches A and B and acts as a short circuit on the secondary of the transformer. This separates the transformer primary and secondary coils a sufficient distance to prevent an excessive current from flowing in the secondary circuit. However, switch C remains closed only until the short-circuited current in the secondary has separated the constant-current-transformer coils, as just described. Then, C, is automatically opened by the clock mechanism and the series lamps are lighted.

NOTE.—A CONSTANT-CURRENT TRANSFORMER CIRCUIT MAY BE CONTROLLED BY AN ORDINARY HIGH-POTENTIAL, OIL-BREAK, DOUBLE-POLE TIME SWITCH (Fig. 469) connected into the primary as indicated in

Fig. 470. With this arrangement, wooden blocks, *W*, are placed between the transformer coils. The thickness of the blocks should be such that when the lamps are off the secondary coil will drop to a position which is just a little below its full-load position.

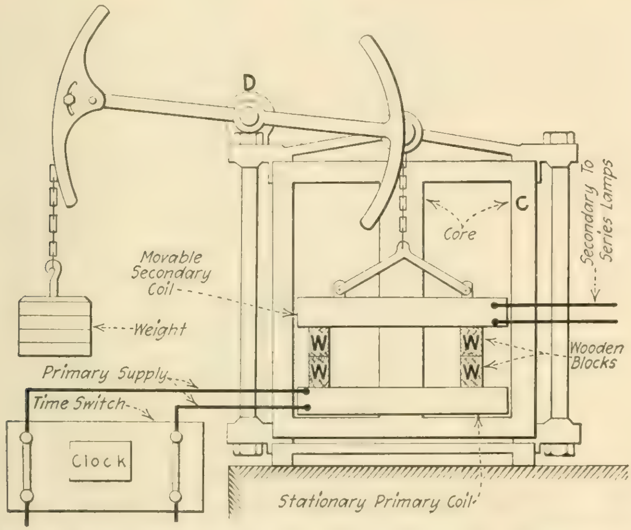


FIG. 470.—Wooden blocks used to keep the primary and secondary coils of a constant-current transformer separated, so the series lamps may not be damaged when the time switch closes.

380. For Controlling A Series-lamp Circuit Which Is Served By A Constant-potential Or Auto-transformer, A Time Switch May Be Used as indicated in Fig. 471. The high-potential, oil-break, double-pole time switch is merely connected into the primary leads which serve the transformer.

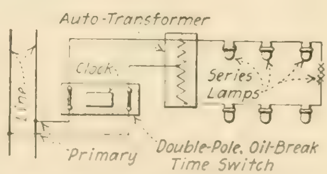


FIG. 471.—Time switch for controlling a series-lamp circuit which is served by an auto-transformer.

381. A Time Switch Designed For Controlling Individual Series Lamps, as illustrated in Fig. 472, is mounted inside of the pole fixture. This switch will not turn the lamp on. This must be done by a patrolman. However, the switch will turn the lamp off after it has burned the number of hours which is indicated by the number

on the dial, *D*, to which the indicator, *I*, points. When set as shown in the illustration, the switch will turn the lamp off 10 hr. after the patrolman turns it on.

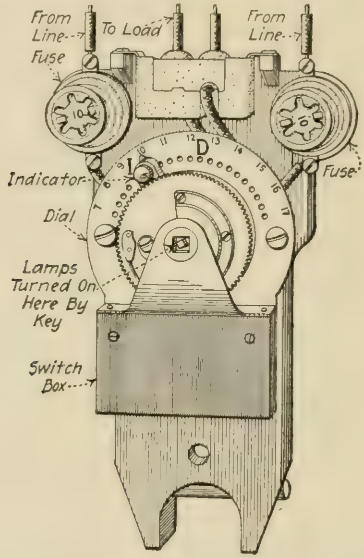


Fig. 472.—Time switch for controlling individual series lamps. (*Type R; A. & J. M. Anderson Mfg. Co.*)

382. In Installing Time Switches, whether indoors or outdoors, it should be remembered that satisfactory operation of the switch depends upon the proper functioning of the clockwork mechanism. Therefore, the instrument should be protected from moisture and dust. The cases of some time switches are made practically dust and moisture proof, whereas some are not so made. Oil-break time switches which are installed on poles or in other exposed places should be enclosed in a wooden housing to provide additional protection against the elements. See Sec. 364 which relates to the electric warming of time switch mechanisms.

383. The Code Requirements For Switches Of Time Switches are the same as those for a manually operated switch (Div. 3). Code Rule 19*d* states that: *Time switches must be of approved design and enclosed in approved cabinets.* Consequently, all approved time switches are enclosed.

NOTE.—THE CASE OF A HIGH-POTENTIAL OIL-BREAK TIME SWITCH SHOULD BE GROUNDED as indicated in Figs. 465 and 469. This is for protection of a workman against a possible insulation breakdown.

QUESTIONS ON DIVISION 8

1. What is a remote-controlled switch? By what other names is it frequently called? Draw a simple sketch of, and explain the operation of a remote-controlled switch.

2. Strictly speaking, in what two ways may a remote-controlled switch be controlled? How are switches which are used to control high-voltage circuits sometimes controlled?

3. For what purposes may remote-controlled switches be used? Give specific examples wherein remote controlled switches are used for lighting service.

4. How may remote-controlled switches be classified according to operation? Define each classification.

5. Why is an electrically-held-closed remote-controlled switch better adapted for the control of motors than a mechanically-held-closed switch?

6. Why is a mechanically-held-closed remote-controlled switch better adapted for the control of lamps than one which is held closed electrically?

7. Name, define, and make a sketch of each of the principal types of remote-controlled switches.

8. Explain with a sketch, the operation of a straight-line-movement' mechanically-held-closed remote-controlled switch.

9. Explain by sketch the operation of a mechanically-held-closed switch of the clapper type.

10. For what service is the *Major* remote-controlled switch especially suited? Why? Make a sketch of the *Major* switch to explain its operation.

11. Explain, with sketch, the operation of an electrically-held-closed remote-controlled switch of the clapper type. By what other names is this type of switch sometimes called?

12. Explain by sketch the operation of an electrically-held-closed, straight-line-movement, remote-controlled switch.

13. Illustrate with a sketch the two separate circuits of a remote-controlled switch.

14. Define the *control circuit* and the *load circuit* of a remote-controlled switch. What constitutes these circuits? Upon what do the control-circuit connections depend?

15. What types of switches are usually employed to control an electrically-held-closed remote-controlled switch?

16. What type of switch is generally used to control a mechanically-held-closed switch?

17. Explain the type of momentary-contact switch which is generally used to control a remote-controlled switch of the mechanically-held-closed type.

18. Draw a sketch of the control-circuit diagram to provide single-location control of the following makes of switches: (*a*) *Hart, Type F.* (*b*) *Cutler-Hammer.* (*c*) *Major.* (*d*) *Sundh.* (*e*) *Automatic.*

19. Draw a sketch of the control-circuit diagram to provide three-location control of those makes of switches which are listed in Question 18.

20. Explain by sketch how a wire-saving may be made in a remote-control installation when the momentary-contact switches are mounted in gang and the remote-controlled switches are mounted on one panel board. If an installation is made according to this method, how much wire will be saved if there are 9 remote-controlled switches which are located 125 ft. from the momentary contact switches?

21. Draw a sketch of the control-circuit diagram to provide single-location control of an electrically-held-closed switch.

22. Draw a sketch of the control-circuit diagram to provide three-location control of an electrically-held-closed switch.

23. Draw a sketch of the control circuit diagram to provide three-location control of an electrically-held-closed switch.

24. Draw a sketch of the control-circuit diagram of a *Hart Type A* remote-controlled switch, wherein single-location control is provided by a single-pole controlling switch. Make a sketch of same, using a two-circuit momentary-contact switch. Describe the type of momentary-contact switch which is required for this service. Explain the difference in the low-voltage protection which is provided by each method.

25. Show by sketch how two or more remote-controlled switches may be controlled by one momentary-contact switch. In a remote-controlled switch wherein the operating current is broken by the switch mechanism, what determines the number of remote-controlled switches which may be controlled by one momentary-contact switch? What determines the number of remote-controlled switches which may be controlled by one momentary-contact switch if the operating current is broken by the momentary-contact switch?

26. Make a sketch of the connections for two remote-controlled switches which are so connected that double-throw switch operation is provided by one momentary-contact switch.

27. Make a sketch of the diagram of connections of two remote-controlled switches so interconnected by a relay that upon failure of the *regular service*, the load will be automatically transferred to the *emergency service*. Explain its operation.

28. Show by sketch how the installation in Question 27 may be remotely controlled.

29. What three sources of electrical energy may be utilized for the control of remote-controlled switches?

30. Name seven different contacting devices whereby a remote-controlled switch may be controlled.

31. Describe the type of remote-controlled switch which should be used when a device other than a momentary-contact switch is used to control it.

32. Draw a sketch of the control circuit of a remote-controlled switch to show how it should be fused to comply strictly with Code requirements.

33. Make a sketch of the control circuit of a remote-controlled switch to show how it is generally fused when used in connection with a system which has a grounded-neutral. Explain why such a method of fusing may be considered safe.

34. Make a sketch to show how the control circuit should be fused when the remote-controlled switch is used to control a circuit which has no grounded-neutral, such as a three-phase, three-wire circuit.

35. How should a remote-controlled-switch circuit be fused?

36. What are the factors which determine whether a remote-control or a direct-control lighting system should be used? What are the conditions which determine these factors?

37. What costs are included in the *annual fixed costs* of an installation? What costs are included in the *annual operating costs?*

38. Explain the general method which should be followed in selecting which system direct-control or remote-control should be used.

39. Make dimensioned sketches (select your own dimensions) to show how a saving may be effected by a remote-control installation over a direct-control installation where the load center, the service entrance and the control location are separated by a considerable distance. How many feet of wire do you save?

40. Make a sketch of the distribution panel of a remote-controlled switch designed for the control several 660-watt branch circuits.

41. Make two sketches of multi-location-control installations of remote-controlled switches, and give two specific examples of their application.

42. Make a sketch of connections for remotely controlling arc lamps in a moving-picture studio. Explain its operation with an actual example.

43. For what types of buildings are remote-controlled switches not usually economical when used as a master switch? Explain by sketch, showing wiring diagram for both the remote- and the direct-control of the master circuit in such a building.

44. Make a diagram of connections of a remote-controlled master circuit, wherein the location controls of the various lamp-groups are provided by single-pole switches.

45. What is a *door switch?* What two types of door switches are frequently used? For what purpose is each type used?

46. For what purpose is a *solenoid door-bolt* switch used? Make a diagram of the connections and explain the operation of a solenoid door-bolt switch. Make a diagram of connections for a solenoid door-bolt switch installation wherein all of the lamps in the room may be controlled by a double-pole room switch, so that no current will flow through the solenoid except when this double-pole switch is closed.

47. What is a *time switch?*

48. Under what conditions are time switches generally desirable?

49. Explain the operation of the *Anderson* time switch; of the *Paragon;* of the *Mercury.*

50. Explain the function of each of the following time-switch appliances: (*a*) *Sunday shut-off device.* (*b*) *Saturday night overtime device.* (*c*) *Warming coil.* (*d*) *Switch-lock-out device.* (*e*) *Electric winding apparatus.* (*f*) *Season changing device.*

51. Give classifications of time switches according to: (*a*) *Type of break.* (*b*) *Type of mechanism.* (*c*) *Operation.*

52. Give the voltage and ampere range for which time switches are suitable when equipped with: (*a*) *Snap switch.* (*b*) *Air-break laminated-copper-brush switch.* (*c*) *Oil-break switch.*

53. Name seven examples wherein time switches are frequently used to control lighting circuits.

54. Can a time switch be used for controlling a circuit other than a lighting circuit?

55. Explain why a time switch may be desirable for controlling electric signs.

56. What type of switch mechanism will frequently be found useful in connection with a time switch used for controlling the lamps in show-windows.

57. What type of switch mechanism should be used in a time switch which is to control a two-rate meter service?

58. What two kinds of transformers may be used to serve series arc or incandescent street-lamp circuits?

59. Explain the operation of one type of time switch which is especially designed for controlling a series street lamp circuit which is served through constant-current transformers. Draw a sketch of the diagram of connections.

60. Make a sketch of and explain how a constant-current-transformer circuit may be controlled by an ordinary double-pole, oil-break time switch.

61. Make a sketch of the diagram of connections for controlling a series lamp circuit, which is served by a constant-potential or auto-transformer, with a time switch.

62. What should be remembered in installing time switches?

63. Give the CODE requirements relating to time switches.

DIVISION 9

THEATRE LIGHTING CIRCUITS AND SWITCHING

384. The Principal Requirements To Be Considered In Laying Out The Circuits For Theatre Lighting are: (1) *Safety of the patrons.* The emergency circuits (Secs. 399 to 402) must be so arranged that every possible precaution against the disastrous result of a panic is provided. (2) *The decorative effect.* The decorative effect which is provided by the lamp-arrangement as made by the architect depends to a large extent on the lighting control. That is, unless the control of the house and stage lights (Secs. 413 and 414) is extremely flexible, those illusions which may be produced by lighting effects, and which are paramount to the success of any show house, cannot be maintained. (3) *Continuity of service,* upon which depends both the safety of the patrons and the decorative effect. (4) *Minimum expense.* By a judicious circuit-layout, both the installation and operating costs may be reduced, and yet comply with the three requirements mentioned above. The general principles pertaining to the arrangement of theatre lighting circuits which are outlined subsequently in this division represent the most modern ideas that are in accordance with the above requirements.

385. The Circuits For A Theatre May Be Generally Classified as: (1) *The services,* (*R, M* and *L*, Fig. 473) which connect the street mains of the public service company to the theatre-service-entrance equipment. (2) *The feeders, mains, and branches* (*F*, Fig. 473) which connect the service-entrance equipment to the various energy-consuming devices and distribution cabinets. (3) *The branch circuits* (Fig. 482) which connect the various distribution cabinets to the lamps. Each of these are discussed subsequently herein.

386. The Service Wires For A Theatre May Be Either Overhead Or Underground. Which type of construction is

used will depend upon local practice and conditions. That is, if the nearby street-main is overhead, the theatre service will be overhead, at least as far as the theatre wall. And, if the street main is underground, the service will generally be underground. However, variation from this practice is sometimes necessitated because of the relative location of the theatre, other buildings, and of the street-main. Underground construction is preferable from the standpoint of safety and maintenance cost, whereas overhead construction is usually less expensive insofar as first cost is concerned.

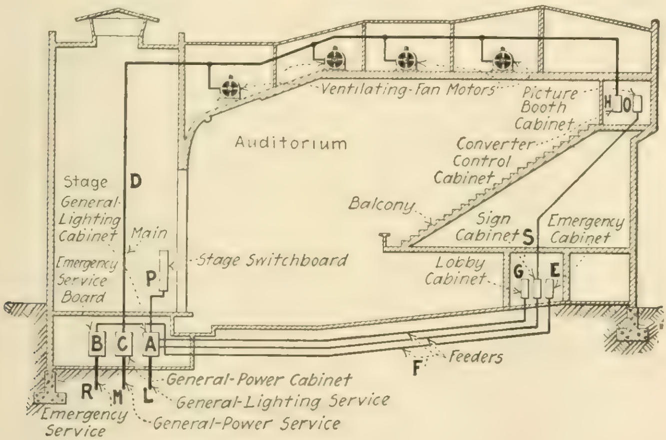


FIG. 473.—Typical theatre-wiring layout showing services, panels, and feeders.

387. Theatres Are Usually Provided With Three Separate Services (Fig. 473) as follows: (1) *The general-power service, M.* (2) *The emergency service, R.* (3) *The general-lighting service, L.* Where the power requirements of a theatre are small, the general power service may sometimes be omitted. The function of each of the above-mentioned services is outlined in the following sections.

NOTE.—A THEATRE SHOULD HAVE AT LEAST TWO SERVICES. (See CODE Rule 38*a*.) If there are only two services, one of these services—the general-lighting service, (Sec. 393)—must have sufficient current-carrying capacity to supply energy for the entire equipment of the theatre while the other service—emergency service, (Sec. 390)—must be at least of sufficient capacity to supply current to all emergency lights (Sec. 402).

389. The Energy Which Is Required To Drive The Various Motors Is Delivered By The General-power Service (*M*, Fig. 473). With the exception of the small motors which drive the projection machine, all motors, such as may be used to drive the ventilating and air-washing apparatus, organ blower, bilge pump, fire pump, vacuum-cleaning apparatus, motor-generator or converter, and the like, are usually served by the general-power service. The small projection-machine motors are driven by current from the general-lighting service (Sec. 407).

390. The Energy For Lighting The Emergency Lamps Is Delivered By The Emergency Service (*R*, Fig. 473). These *emergency lamps* consist of those lamps which always remain lighted throughout the entire program, such as the aisle lamps, exit-door lamps, a portion of the lamps in the foyer, lobby, stairways, corridors, courts, and other portions of the theatre to which the public has access. See Sec. 402.

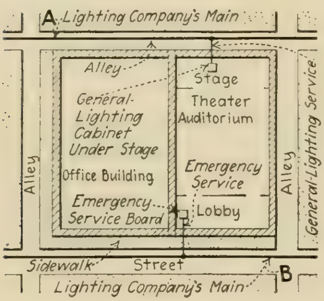


Fig. 474.—Where feasible, the emergency service and the general-lighting service are connected to separate street mains.

391. Where Feasible, The Emergency Service And The General-lighting Service Must Be Connected To Different Street Mains, as suggested in Fig. 474. Where it is impractical to do this, the emergency-light feeder must be connected to a point on the street side of the main service fuses as shown in Fig. 475. In some installations where only one street-main is available, two separate services are run to the street-main and preferably connected to two separate transformers but sometimes to the same transformer, as shown in Fig. 476. Then, if frequent energy-supply failures occur, it may be necessary to have the lighting company run another main up to the point where the emergency service connects to the transformer; whereupon, the emergency service is then connected to the new main and a new transformer.

NOTE.—SOME CITIES REQUIRE, IN ADDITION TO THE REGULAR EMERGENCY SERVICE, AN AUXILIARY STORAGE-BATTERY ENERGY-SUPPLY FOR THE EMERGENCY CIRCUITS. The city of Cleveland requires this. The storage battery is only used when the regular emergency service fails. The storage-battery circuit and the regular emergency service are connected to the emergency-cabinet feeder through a double-throw switch. Frequently, this double-throw switch is so operated by a

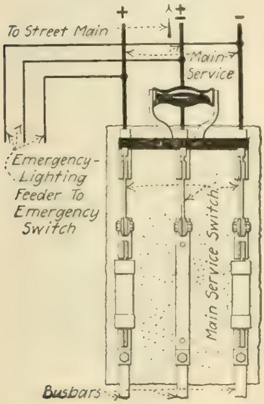


FIG. 475.—Showing method of connecting emergency-lighting feeder to main service on the street-side of the main service switch.

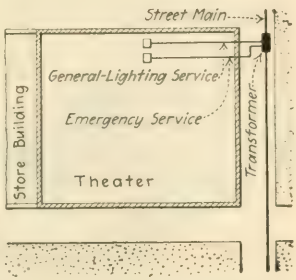


FIG. 476.—Showing emergency service and general lighting service connected to same transformer.

relay (Sec. 335) that when the regular emergency service fails, the switch is automatically thrown over and connects the emergency circuit to the storage-battery circuit.

392. The Reason For The Separate Emergency Service is to provide every reasonable assurance against failure of the "emergency" lights, which supply sufficient illumination to enable patrons to see their ways out of the theatre in case of failure—fuse-blowout due to short-circuit or ground—of the general-lighting circuit. Hence, only porcelain, keyless sockets serving only incandescent lamps, in which No. 14 or larger wire is carried direct to the socket, is permitted on these circuits. Fans cannot be served from emergency circuits. *The wattage of each emergency-circuit branch is limited to 660 watts.*

NOTE.—THE GENERAL-LIGHTING CIRCUIT IS MORE SUSCEPTIBLE TO TROUBLES THAN IS THE EMERGENCY CIRCUIT. This is because of the

fact that portable equipment, such as olivettes and bunch-lights are often plugged in on the general lighting circuit by means of stage pockets (Fig. 477). Grounds or shorts may occur in the cords which feed this equipment. It is a fact that all of these circuits should be properly protected with N.E.C. fuses. But in practice they are likely to be "fused" with nails, copper wire, or any other metal which the electrician finds handy when he is endeavoring to close a circuit quickly so that the performance may proceed. Furthermore, the apparatus in the projection booth—motion-picture machine and stereoptican arc lamps—and the motors which operate the projector and the rewinding machine, are all

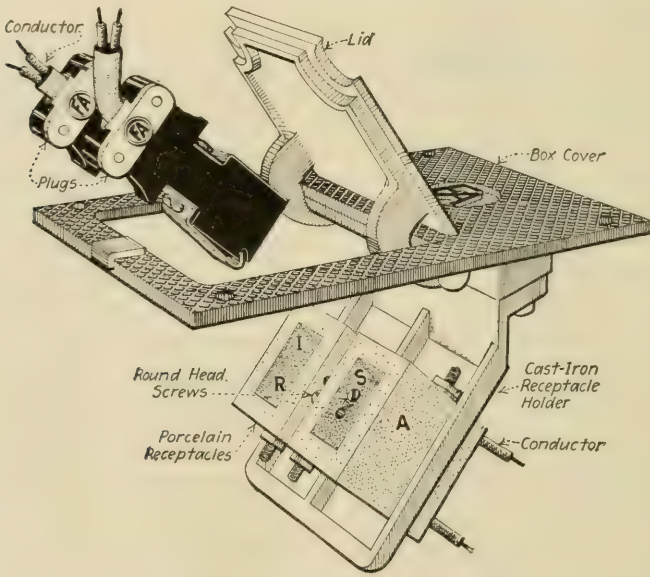


Fig. 477.—A two-receptacle stage pocket. (*Frank Adam Electric Co.*)

served from the general-lighting circuit (see *O*, Fig. 482). This equipment, which is used almost continually, is liable to be the source of troubles which will interrupt the general-lighting-circuit energy supply.

Note.—A Combination Non-interchangeable Arc-and-incandescent Stage Pocket is shown in Figs. 477 and 478. A groove (*G*, Fig. 479) is provided in the side of each plug. In the incandescent plug (Fig. 479-*I*), the groove, *G*, is in the lower part, and in the arc plug (Fig. 479-*II*), the groove is in the upper part. If a round-head screw, *S*, is put in the upper of the two holes of the receptacle *A* (Fig. 477), that receptacle becomes the arc receptacle. This is because, on account of the groove (*G*, Fig. 479-*II*), only the arc plug can be inserted therein. If the screw is inserted in the lower hole, as shown at *R*, that receptacle,

I, (Fig. 477) becomes—on account of the groove, *G*, in the incandescent plug, Fig. 479-*I*—the incandescent receptacle. Thus, when one screw is put in the upper hole of one receptacle, and another screw is put in the lower hole of the other receptacle, the arc and incandescent plugs are non-interchangeable.

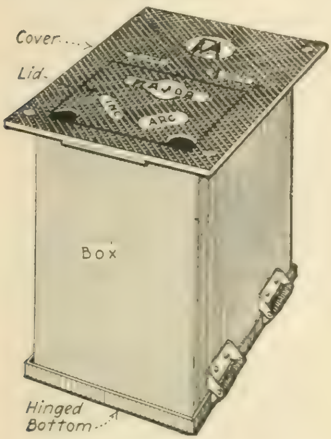


Fig. 478.—Steel box for stage pocket.

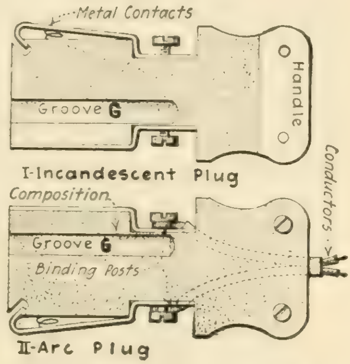


Fig. 479.—Arc and incandescent plugs for a combination stage pocket.

393. The Energy Which Is Delivered By The General-lighting Service (*L*, Fig. 473) is used to light all lamps in the theatre except (Sec. 390) the emergency and exit-sign lamps. That is, the general-lighting service carries the current for the lamps which light the: (1) *Stage.* (2) *Auditorium.* (3) *Offices.* (4) *Signs.* (5) *Toilets.* (6) *Dressing rooms.* (7) *Rest rooms.* (8) *General illumination of foyer and lobby.* The distribution centers which are fed by feeders from the general-lighting cabinet are given in Sec. 404.

Note.—The Voltage And The Kind Of Current-supply For Theatres will usually be that which is the more-readily available. However, the general practice is to use 110/220 volt, three-wire, single-phase supply for the emergency- and the general-lighting circuits. The current for the power circuit is usually supplied at 220 volts, three phase.

394. Each Service Must Be Provided With A Separate Service Switch, Service Fuses And Meter. The service switch and service fuses must, in general, be so wired and

located as to comply with the Code requirements as outlined in Div. 3 for service entrances. The service switches and the main distribution panels may, if they are located in a separate room which is accessible only to properly-informed persons, be mounted on an open switchboard. However, if they are not so located, they must be enclosed in suitable metal cabinets.

Note.—The Type Of Service Fuses which are generally used for capacities of 800 amp. and below is the N.E.C. Standard (cartridge, or enclosed). For capacities of 1,000 amp. and above, open-link fuses or circuit-breakers are nearly always used. The cities of Chicago and Cleveland compel the use of circuit-breakers for capacities greater than 1,000 amp.

395. The Most Desirable Location For The Service Boards service switch, service cutout, and meter—for each of the services (Sec. 387) is usually in the basement under the stage

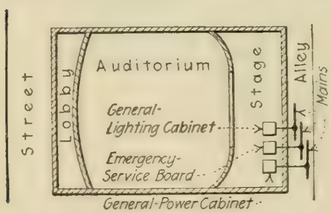


Fig. 480.—Service boards in stage-basement.

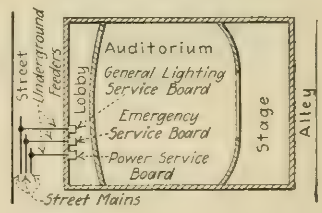


Fig. 481.—Service boards in lobby-basement.

(Fig. 530), as suggested in Figs. 473 and 480. The principal reasons for this are: (1) *The street mains are usually in the back alley and are nearer to the stage-basement than to any other part of the theatre.* (2) *There is usually more available space in the stage-basement.* (3) *They are readily accessible to the electrician.* During the performance, the electrician is usually on the stage. Consequently, if trouble at the service boards develops, it may, if they are under the stage, be more quickly corrected by him than if the boards were located at the front of the building.

Note.—It Is Sometimes Impractical To Locate The Service Boards In The Stage-basement. Inspection departments usually require that the service-entrance equipment be located as near as possible to the point (not over 3 ft. distant, unless lead-covered cable in iron con-

duit is used) where the service enters the building. Therefore, if the public service company's mains are in the street in front of the theatre, it may, since in such cases the feeders are usually run underground, be more desirable to locate the service boards in the basement under the lobby as shown in Fig. 481. Whether the service boards are located under the lobby or under the stage will not materially affect the general locations (see following sections) of the various distribution cabinets.

396. The Diagrammatic Plan For A Theatre Circuit Layout which is illustrated in Fig. 482, typifies that which is used in

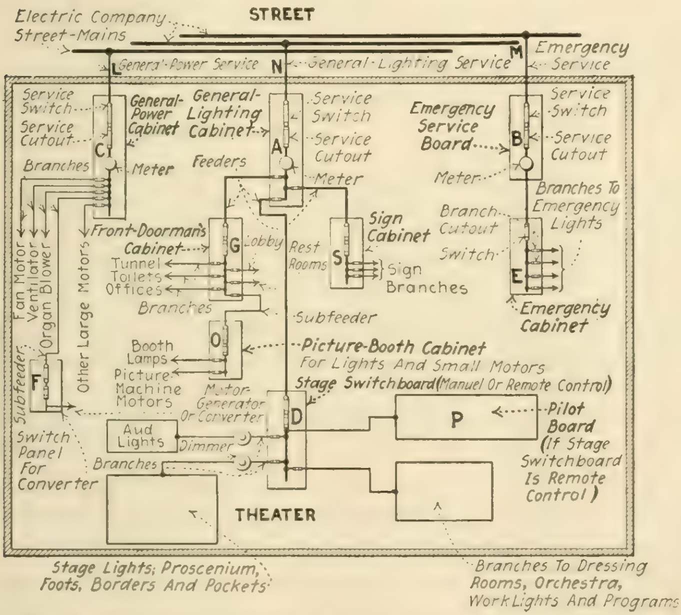


Fig. 482.—Showing diagrammatically a general scheme of circuit lay-out for theatre wiring.

practically all medium and large-size modern theatres. However, local conditions may necessitate slight variations from this general scheme. The plan as shown consists of three separate sets of services: (1) *The general-power service, L*, which supplies the current required for the large motors. (2) *The emergency service, M*, which supplies current for the emergency lamps. (3) *The general-lighting service, N*, which supplies current for lighting the stage, auditorium, basement, lobby,

offices, signs and the like. The circuits employed for distributing the energy which is supplied by each of these three services are discussed in subsequent sections.

397. The General-power Cabinet (*C*, Fig. 482) usually consists (see Figs. 536 and 552) of a combination of the service-entrance equipment—switch, fuses and meter—and the distribution panel for distributing the energy to the various motors. The reason for combining the service-entrance equipment and the distribution center at the same cabinet is because the center of the motor load is usually near the stage-basement, which is also near the service entrance. However, if the center of the motor load is far removed from the service entrance as shown in Fig. 483, the general-power service board may consist only of the service-entrance equipment. In such cases, the power-distribution panel (*D*, Fig. 483) is located near the center of the motor load. Then, it is connected to the power service board, *C*, by a single set of feeders, *F*.

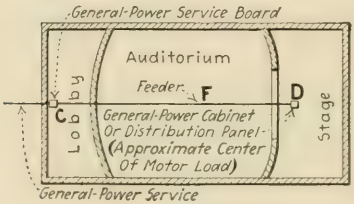


Fig. 483.—When the center of the motor load is located at a considerable distance from the service entrance, then the distribution panel is located near the motor-load center and connected to the general power service board by a set of feeders.

398. The Control Panel For The Converter Or Motor-generator In The Picture Booth (*F*, Fig. 482), is fed by a separate set of sub-feeders from the general-power cabinet. This control panel usually consists of only a sheet steel-enclosed externally-operated knife-switch (Fig. 556-*II*) which is properly fused for the protection of the switch and branches.

399. The Emergency Service Board (*B*, Fig. 482) nearly always consists of a properly-fused, externally-operated enclosed knife-switch (see Fig. 555-*II*), provided with meter-loops and two sets of connecting lugs. The service wires are connected to one set of these lugs. The meter and the feeders which supply the emergency distribution panel (Sec. 400) are connected to the other set of lugs. The emergency service board is, even when the emergency-service entrance is at the front of the theatre (Fig. 474), seldom combined with

the emergency distribution panel. This is because (Sec. 395) the emergency-service entrance, and therefore the emergency service board are usually in the basement, and the emergency distribution panel is (Sec. 401) practically always installed in a room which is located on the first floor.

400. The Emergency Cabinet (*E*, Fig. 482) is the distribution center for the current which lights the emergency lamps. This cabinet consists (Fig. 546) of an unfused switch and busbars for distributing current to the various plug-fused branches. The switch, busbars and fused-connections are mounted on a suitable base of non-insulating material—usually slate—and the whole is enclosed in a metal cabinet. For a typical example of the circuits fed from an emergency cabinet (see Sec. 452, Clause 34).

Note.—The Branch-circuit Connections Of An Emergency Cabinet May Or May Not Be Equipped With Branch-circuit Switches. It is considered good practice, and a number of the larger cities require that these branch-circuit switches be omitted. The reason for the omission of these switches is because experience has shown that if they are provided, the manager will, during an afternoon performance, turn off all of the emergency lamps (Sec. 452, Clause 34, E-18) on the fire escapes, and in alleyways and courts outside of the theatre proper. Then if someone forgets to turn them on for the evening performance and a fire or panic occurs, it may be disastrous for the people from the galleries and balconies to rush out upon unlighted fire escapes.

401. The Emergency Cabinet Should Be Located In The Front Portion Of The House (see Fig. 531 and Code Rule 38*t*, Par. 3). It is usually installed in the lobby, foyer, front-doorman's closet, box office, manager's office, or in some other place which is readily accessible.

Note.—The Emergency-cabinet Main Switch (Sec. 400) may be of a type which is manually operated or remotely controlled. If it is a remote-controlled switch, the remotely-controlling momentary-contact push switch is usually enclosed in a glass-front cabinet and installed on a side wall of the lobby or vestibule (Fig. 531) just inside the main doors, (see Code Rule 38*t*.) This glass front cabinet is provided with a door and a lock, so that only authorized persons may normally have access therto. The glass front is sometimes lettered with the words, "*In Case Of Fire Break Glass And Push The Button.*" Then if a fire occurs when no one is in the theatre, the firemen may, by operating this momentary-contact switch, light the emergency lamps.

402. The Emergency Lamps Should Be Of Sufficient Rating And Should Be So Arranged that, if all other lights fail, they will provide a well-lighted pathway from all parts of the theatre

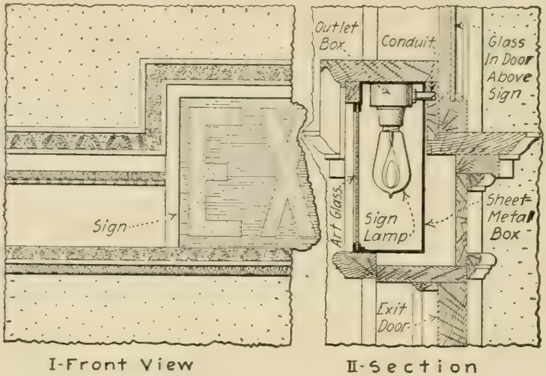


FIG. 484.—Details of exit sign. (The word "Exit" is so rendered on the glass that it appears red.)

to the street. Also, since they must be kept burning during the performance, the illumination provided thereby must not be excessive or a "dark-house" effect cannot be obtained. Experience has shown that one 60-watt lamp, or the equiva-

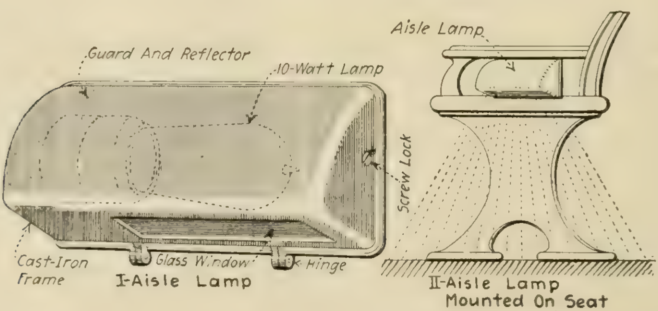


FIG. 485.—A 10-watt aisle-lamp fixture connected to the emergency circuit and mounted on seat. (*The Brookins Co.*)

lent thereof, for each 400 sq. ft. of main-auditorium and balcony-floor space (0.15 watts per sq. ft.) will, if properly located, meet the above requirements. The lamps within

the theatre which are connected to the emergency circuits are: (1) *Exit-sign lamps* (Figs. 484). (2) *A sufficient number of wall and ceiling lamps in main auditorium, balcony, corridors, stairways, foyer, lobby, and all other places within the theatre which are generally accessible to the public,* to provide at least the average wattage per square foot as given above. (3) *Aisle lamps* if any, (Figs. 485, 486 and 487). In addition to the above-mentioned lamps, all outside alleyways, courts, or

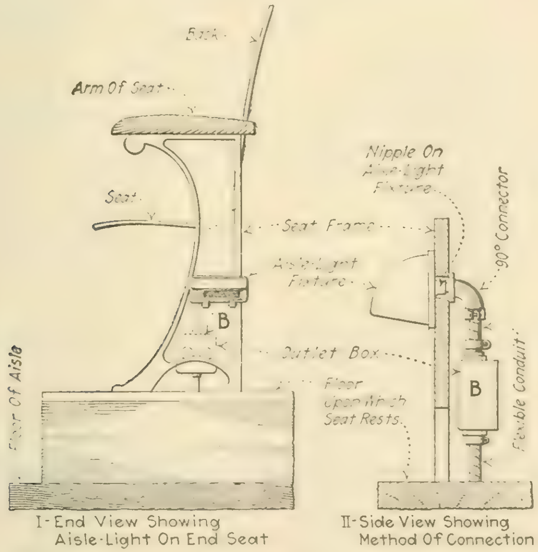


Fig. 486.—Showing method of wiring an aisle-light fixture, when aisle lights are provided after theatre has been finished. In a new building, the outlet box, *B*, may be installed flush with the floor.

fire escapes, which may be used by the public in going from a theatre exit-door to the street should be well illuminated by lamps which are connected to the emergency circuit.

Note.—Any Emergency Lamp Should Not Have More Than One Set Of Fuses (those in panel *E*, Fig. 482) between it and the main emergency-service fuses (those in panel *B*, Fig. 482). See Code Rule 38*l*, Par. 2.

Note.—Although The Exit-sign Lamps Are On The Emergency Circuit, Strictly Speaking They Are Not Emergency Lamps. It is only intended that the exit-sign lamps shall act as markers to indicate

the location of the exit doors. The exit-sign lamps are not intended to provide any illumination, and therefore are not to be considered in computing the total emergency-lamp wattage. In many cities, the exit signs must be provided with both gas and electric illumination. In such places, if gas is not available, the exit sign must, in addition to the electric lamp, be provided with an oil lamp.

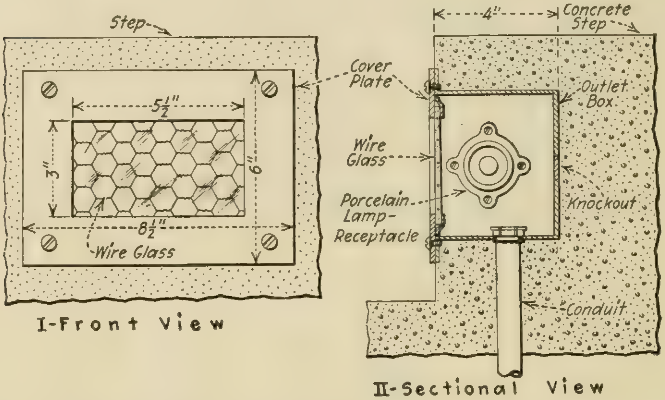


Fig. 487.—Flush type aisle light for stairway or hallway. (*Frank Adam Electric Co.*)

403. The General-lighting Cabinet (*A*, Fig. 482) usually consists (Fig. 535) of a combination of the service-entrance equipment—service switch, meter loops, and service fuses—and the necessary busbars and fused-connections for the various feeders which supply energy to the cabinets that are mentioned in the following section. The general-lighting service board and the cabinet containing the distribution center for the feeder connections may, as suggested in Sec. 395, be separate and located in different parts of the building. However, this is the exception and not the rule. The two are usually combined and located (Fig. 530) in the basement under the stage.

404. The Distribution Centers, Or Cabinets, Which Are Ordinarily Fed Through Feeders From The General-lighting Cabinet are (see Fig. 550): (1) *Sign Cabinet.* (2) *Front-doorman's Cabinet.* (3) *Dressing Room Cabinet*, if any. (4) *Shop Cabinets,*—business places, offices and stores—if any. (5) *Stage Switchboard.* Each of these cabinets and the branch

circuits which are fed therefrom are described in detail in the following sections.

405. The Sign Cabinet (*S*, Fig. 482) which serves the electric signs and which is fed (Fig. 550) from the general-lighting cabinet (Sec. 403) by a separate set of feeders, is usually located along side of the front doorman's cabinet (Sec. 406). However, in some installations which have a heavy sign-lighting load, the center of which is far above the street level, it may be more economical to install the sign cabinet (*S*, Fig. 488) in some suitable place on the third or fourth floor near the

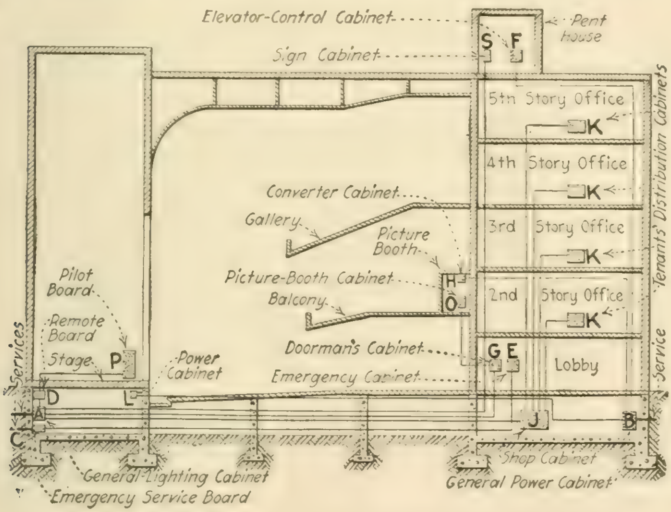


FIG. 488.—Riser diagram for combined theatre and office building.

sign load center. In such an installation, the sign-cabinet switches are usually of the remote-controlled type. Then, the sign cabinet is fed by a direct feeder from the general-lighting cabinet, and only the necessary control wires for the remote-controlled switches are run from the sign cabinet to the controlling momentary-contact switches which are installed in the box office, manager's office, or in the trim of the front-doorman's cabinet. The design of the sign cabinet will depend upon the signs which are to be served. In general, this cabinet consists (Fig. 547) of the busbars, and a number of knife or remote-controlled switches, each of which controls

a number of fused 660- or 1,320-watt branch circuits. The sign cabinet serves (Sec. 452, Clause 36) such signs outside the building as the roof signs, outside-entrance canopy lamps, attraction signs, and the like.

406. The Front-doorman's Cabinet (**or Lobby Cabinet,** *G*, Fig. 482) is usually located (Fig. 531) somewhere in the front portion of the theatre near the lobby or foyer, and preferably in a room which is near the front-doorman's station, such as the front-doorman's closet, the check room or some similar place. This cabinet is generally provided (Fig. 545) with an unfused main switch and bus-bars which feed the required number of 660- or 1,320-watt plug-fused branch circuits. Each of these branch circuits is generally equipped with a branch-circuit switch. These branch circuits serve all lamps which are used for general illumination in the front portion of the theatre (Sec. 452, Clause 32), such as the lights in the lobbys, foyers, canopy, picture booth, corridors, stairways, ladies' and men's parlors, check rooms, box office, manager's office, ushers' rooms, janitors' closet, and the like. The front-doorman's cabinet is sometimes called the *lobby cabinet.* For a typical example of the circuits served by the front-doorman's cabinet, (see Sec. 452, Clause 32).

NOTE.—SOME OF THE BRANCH CIRCUITS OF THE FRONT-DOORMAN'S CABINET SHOULD BE SO CONNECTED AHEAD OF THE MAIN SWITCH that they will not be disconnected from the energy source when the main switch is open. In general, the branches which should be so connected (Sec. 452, Clause 31) are those which serve the picture-booth cabinet, the lights in the manager's office, box office, ushers' rooms and janitors' closets. The reason for this is that the above mentioned circuits may be switched on by their individual branch-circuit switches without having to close the cabinet main switch. If it is necessary to close the main switch of the front-doorman's cabinet to light the above-mentioned places, the janitors or ushers will, when entering the building during the day, close the main switch and fail to turn off the other branches which are in this cabinet, thus causing a large energy-waste.

407. The Picture-booth Cabinet, (*O*, Fig. 482) which is located (Fig. 531) in the picture booth, is fed by a set of subfeeders—usually two No. 12 wires— from the front-doorman's cabinet (Sec. 452, Clause 39). The picture-booth cabinet usually consists (Fig. 548) of a four-circuit panel, each branch-

circuit connection being provided with a set of fuses and a switch. One of these branches serves the lamps for lighting the picture booth and the converter room. The other three branches usually serve the two picture-machine motors and the rewind motor.

408. A Profitable Current-saving May Sometimes Be Effected By A Careful Selection Of The Circuits To Which Those Lamps In The Front Portion Of The Building Are Connected. For example, if the lamps in the lobby and on the canopy are properly divided (see Sec. 452; Clause 34, *E*-1 and *E*-2; Clause 32, *G*-1, *G*-2, *G*-6, *G*-7 and *G*-37 to *G*-42; and Clause 36, *S*-1 and *S*-3) between the emergency cabinet, the front-doorman's cabinet and the sign cabinet, it may be profitable, after the performance is well under way to turn out some of the lamps in the front part of the building. That is, turn out some of the outside entrance-canopy lamps which are served from the sign cabinet, or turn out some of the canopy or lobby lamps which are served from the front-doorman's cabinet. Then, the lamps which are on the emergency circuit, and those that are served by the front-doorman's cabinet and the sign cabinet which have not been turned out, must give the desired illumination for this portion of the building.

409. A Dressing-room Cabinet is sometimes used in those installations where there are a large number of dressing rooms. When used, this cabinet is ordinarily installed in the stage-doorman's closet. This cabinet should consist of a cabinet main switch, the busbars for feeding the required number of 660-watt fused branch-circuit connections, and branch-circuit switches. This cabinet serves the lights in the dressing rooms, musicians' rooms, furnace room, passage ways, and all other parts of the stage basement. When a dressing-room cabinet is provided, it is fed and controlled (see switch No. 25, Fig. 500) from the stage switchboard. In installations where a dressing-room cabinet is not used, the distribution center for these circuits is (Sec. 452, Clause 28) at the stage switchboard, from whence they are controlled.

410. A Shop Cabinet (*J*, Fig. 488) is usually employed to feed the shops or offices which may be contained in the theatre

building. This cabinet, which is located (Sec. 452, Clauses 44, 45 and 46) near the shop load, is fed (Fig. 550) by a separate set of feeders from the general-lighting cabinet (*A*, Fig. 488). If the owner of the building furnishes light to the tenants, all of the power used for lighting the building is usually metered at *A*, Fig. 488. Thus, the power can usually be purchased at a lower rate, than if the lighting power which is used by the tenants is metered separately. However, if each tenant pays for his own power, the feeder which supplies *J* may be connected (Fig. 535, circuits 2 and 3) ahead of the meter loops at *A*, Fig. 488. Then a separate meter for each tenant is connected into the various sub-feeders at *J*. A separate distribution panel, *K*, which is fed from *J*, is then provided for each tenant.

411. The Stage Switchboard (*D*, Fig. 482) is fed from the general-lighting cabinet. The terminology, types, and circuits of stage switchboards will now be treated.

412. The Lights Which Are Generally Controlled From The Stage Switchboard May Be Classified as: (1) *The house lights.* (2) *The stage lights.* (3) *The work lights.* Each of these terms is hereinafter defined.

413. The House Lights (see Sec. 452, Clause 30, *D*-38 to *D*-48) are those lights which are used for the general and decorative illumination of the auditorium and balcony. *These lights are usually of one color, or of three colors.* If the house lights are of only one color, they are usually white or amber. If there is more than one color of house lights, the colors which are provided are usually white or amber, blue, and red. In such a three-color installation, the sum of the number of the blue lamps and the red lamps is practically always equal to the number of white lamps. However, sometimes the house lights consist of equal numbers of white or amber, red, and blue lamps.

414. The Stage Lights are those lights (see Sec. 452, Clause 30, *D*-2 to *D*-36) which are used to provide the illumination and the decorative effect of a scene on the stage. The principal stage lights consist of: (1) *The footlights.* (2) *The proscenium lights.* (3) *The border lights.* (4) *The arc and incandescent pocket lights.* Frequently other stage lights are

provided, such as spot lights located in the ceiling over the orchestra pit. The stage lights nearly always consist of three colors; white, red, and blue, in the same proportions as that given in Sec. 413 for the house lights.

NOTE.—THE NUMBER, WATTAGE, AND LOCATIONS OF THE VARIOUS STAGE LIGHTS for proper illumination of stages of different dimensions may be determined from the data as tabulated in Figs. 488A and 488B. These illustrations are self-explanatory.

For 4 Color These Lamps To Alternate White And Amber

Width Of Proscenium Arch "W"	"FL" In Feet	50 Watt Clear Lamps 3" C To C	White Foots Total Watts	50 Watt Red Lamps 6" C To C	Red Foots Total Watts	50 Watt Blue Lamps 6" C To C	Blue Foots Total Watts	3-Color "Br" In Feet	3-Color "F" In Feet	3-Color 300 W. Work Lts.	3-Color Watts Per Color	3-Color 300 Watt Lamps Per Color	4-Color "Br" In Feet	4-Color "F" In Feet	4-Color 300 W. Work Lts.	4-Color Watts Per Color	4-Color 300 Watt Lamps Per Color
20	16	64	3,200	32	1,600	32	1,600	16	2	1	1,500	5	17	1½	1	1,200	4
25	21	84	4,200	42	2,100	42	2,100	19	3	1	1,800	6	21	2	1	1,500	5
30	25	100	5,000	50	2,500	50	2,500	22	4	1	2,100	7	25	2½	1	1,800	6
35	30	120	6,000	60	3,000	60	3,000	25	5	1	2,400	8	29	3	1	2,100	7
40	34	136	6,800	68	3,400	68	3,400	28	6	1	2,700	9	33	3½	1	2,400	8
45	39	156	7,800	78	3,900	78	3,900	34	5½	1	3,300	11	37	4	1	2,700	9
50	43	172	8,600	86	4,300	86	4,300	37	6½	1	3,600	12	41	4½	1	3,000	10
55	48	192	9,600	96	4,800	96	4,800	44	5½	2	4,200	14	46	4½	2	3,300	11
60	52	208	10,400	104	5,200	104	5,200	47	6½	2	4,500	15	50	5	2	3,600	12
65	57	228	11,400	114	5,700	114	5,700	53	6	2	5,100	17	54	5½	2	3,900	13
70	62	248	12,400	124	6,200	124	6,200	59	5½	2	5,700	19	58	6	2	4,200	14
75	67	268	13,400	134	6,700	134	6,700	62	6½	2	6,000	20	62	6½	2	4,500	15
80	71	284	[illegible]	142	7,100	142	7,100	68	6	2	6,600	22	66	7	2	4,800	16
85	76	304	[illegible]	152	7,600	152	7,600	74	5½	2	[illegible]	24	74	5½	2	5,400	18
90	80	320	[illegible]	160	8,000	160	8,000	80	5	2	7,800	26	78	6	2	5,700	19
95	84	336	[illegible]	168	[illegible]	168	8,400	83	6	2	8,100	27	82	6½	2	6,000	20
100	84	336	[illegible]	168	8,400	168	8,400	86	7	2	8,400	28	86	7	2	6,300	21

FIG. 488A.—Chart showing numbers of and wattage of lamps for foot and border lights for stages, based on depth of stage and width of proscenium opening as indicated in Fig. 488B. (*Copyright by Frank Adam Electric Co., St. Louis, Mo.*)

415. The Work Lights (see Sec. 452, Clause 28) are all of those lights, that are controlled from the stage switchboard, which are used to provide illumination for the theatre employees. The work lights generally consist of the orchestra lights, gridiron lights, fly-gallery lights, dressing-room lights, bracket lights located on the walls back of the stage, and the like. All of the work lights are white lights. The gridiron or *rigging loft* is the open floor formed by the horizontal framework which carries the pulleys over which the lines pass

whereby the drops, border lights and the like are raised and lowered. The gridiron occupies the space over the stage near the roof.

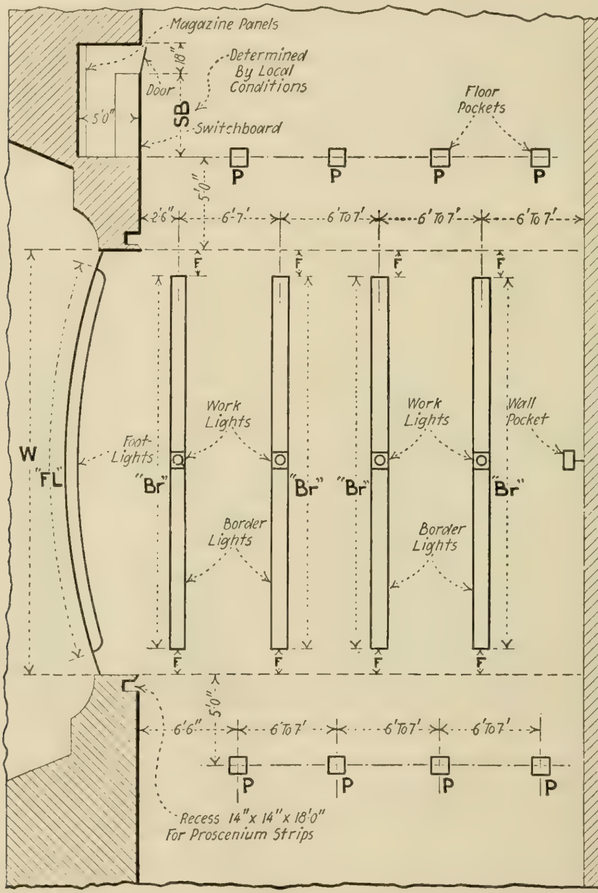


Fig. 488B.—Diagram of stage and proscenium for dimensions which are tabulated in Fig. 488A. (*Copyright by Frank Adam Electric Co. St. Louis, Missouri.*)

416. The Following Are Definitions Which Relate Specifically To Stage Switchboards And The Circuits Controlled Therefrom:

A Remote-control Switchboard is a complete equipment whereby switching is effected by remote-controlled switches. An electrically-

operated remote-control switchboard comprises two essential elements: (1) *The pilot board* (Fig. 507). (2) *The remote board* (Fig. 508).

A REMOTE BOARD (Fig. 508) is an equipment comprising remote-controlled switches, the required busbars, and the supporting structure. A remote board, usually consists of a structural steel frame, on which are mounted the remote-controlled switches, together with the necessary wiring and busbars for connecting the remote-controlled switches with the circuits controlled by them. When the board is not installed in a fireproof room or vault, it is enclosed in a sheet steel cabinet which can be locked.

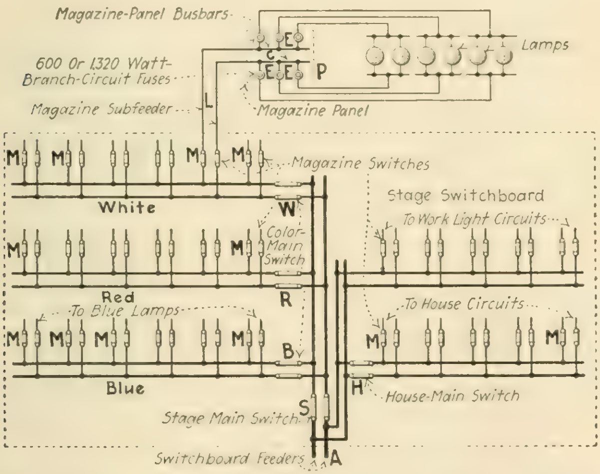


FIG. 489.—Diagram to illustrate stage switchboard nomenclature. All of the sub-feeders which feed house and stage circuits feed through magazine panels as shown above at *P*.

THE STAGE SWITCHBOARD FEEDERS (*A*, Fig. 489) are the conductors which connect the general-lighting cabinet to the stage switchboard busbars.

THE STAGE-MAIN SWITCH OR "STAGE MAIN" is the switch (*S*, Fig. 489) through which all of the current flows for lighting the stage lights (Sec. 414). Thus, when the "stage main" is open none of the stage lights can be illuminated. This switch is also sometimes called ***the stage-master switch*** or ***the stage-bull switch.***

THE HOUSE-MAIN SWITCH OR "HOUSE MAIN" (*H*, Fig. 489) is the switch through which all of the current flows for lighting the house lights (Sec. 413). This switch is also called *the house-master switch* and ***the house-bull switch.***

A COLOR-MAIN SWITCH OR "COLOR MAIN" (*W*, *R*, and *B*, Fig. 489) is a switch through which all of the current flows for lighting the stage lights

(Sec. 414) or the house lights (Sec. 413) of any one color. Thus, if the "white main" (W, Fig. 493) is open, none of the lights—"stage whites"—which are controlled by switches Nos. 10, 7, 4, 1, 16 and 13 (Fig. 493) can be lighted. Color main switches are usually provided on a manually-operated (Sec. 423) non-interlocking switchboard. On a manually-operated interlocking switchboard (Sec. 424), the function of a color-main switch is performed by a master lever (B, R, and W, Fig. 494). A color-main switch is also sometimes called *a color-master switch*, or *a bull switch*.

A Magazine Switch (M, Fig. 489) is a switch through which all of the current flows for lighting the lamps which are connected to one section of the magazine panel.

A Magazine Sub-feeder (L, Fig. 489) is a set of conductors extending between a magazine switch and a magazine panel and through which electrical energy is supplied to a section of the magazine panel.

A Magazine Panel (P, Fig. 489) is a distributing panel for such 660- or 1,320-watt branch circuits as are fed through the magazine switches of the stage switchboard. Thus a magazine panel comprises the bus-bars, C and the branch-circuit fuses, E, through which the magazine circuits are fed.

A Magazine Circuit (Fig. 489) comprises all of the 660- or 1,320-watt branch circuits, which serve the various outlets that connect to the bus-bars of one section of the magazine panel. A magazine circuit may consist of only one 660- or 1,320-watt branch circuit.

A Pilot Board (Fig. 507) is the switchboard, in a remote-control installation, which comprises the pilot switches, the inter-connecting conductors between the pilot switches and the supporting structure for both.

An Individual Pilot Switch (Fig. 510) is a switch on a pilot board which is so connected that it can be used only to control the electromagnet circuits of one remote-controlled switch. A pilot switch is a remotely-controlling switch.

A Sub-master Pilot Switch is a pilot switch which is so connected that it may be used to control the electromagnet circuits of two or more remote-controlled switches.

A Master-pilot Switch is a pilot switch which is so connected that it may be used to control the circuits of two or more sub-master pilot switches.

The Constant-circuit Switches (Fig. 519) on a stage switchboard are the switches, which open or close the circuits to the rigging-loft, orchestra, attic and sometimes the dressing-room lights, and the lights in other places where stage or auditorium lighting effects are not required. The circuits which these constant-circuit switches open and close are not fed through the "main" switch, if any, and are not controllable by a pilot switch if any (see Sec. 415). The *work lights* are controlled by constant-circuit switches.

417. The General Scheme Of Circuit Control Which Is Usually Provided On All Stage Switchboards is indicated in Fig. 490. Nearly all theatre stage switchboards control more circuits than are shown in Fig. 490. For example there may be three borders, instead of only one, as shown. If there were, say, three borders, the white lights of borders Nos. 2 and 3 would be provided with a separate magazine-panel section, dimmer, and magazine switch, and would be

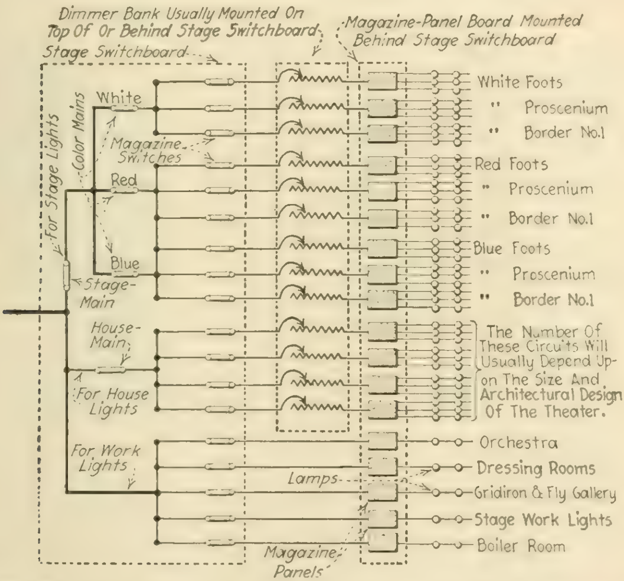


FIG. 490.—Illustrating the general scheme of circuit control which is usually provided on stage switchboards.

connected in a manner similar to that for Border No. 1. If the house lights consist of three colors, the house circuit would be subdivided according to colors in a manner similar to that employed for the stage circuit. For specific examples of actual stage switchboards, see subsequent sections.

418. The Requirements Of Stage Switchboards Are Very Exacting. The currents which must be handled are relatively large. Furthermore, space on the stage at the side of the proscenium arch where the switchboard must always be located is at a premium. Therefore, it is essential that the switch-

board equipment be compacted into minimum space (Fig. 490A). Also, every precaution must be taken to insure that the stage switchboard will function properly at all times. If it should fail while a show was in progress, the result would be commercially disastrous.

Note.—Flexibility Of Control Is Probably The Most Exacting Operating Requirement Of A Stage Switchboard. That is, the design and construction of the board should be such that the stage electrician can instantly switch in or out of service any combination of any of

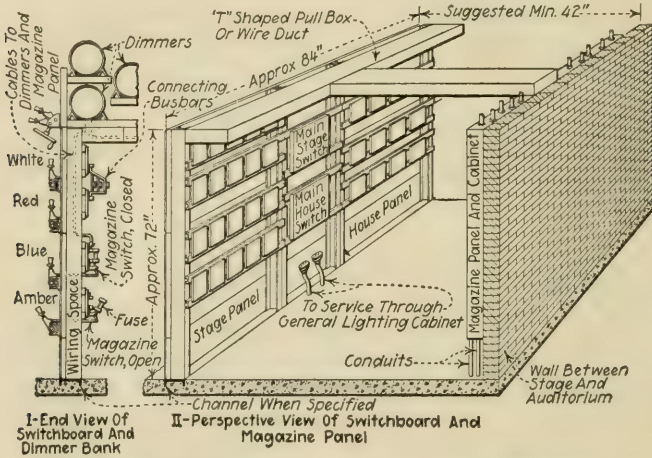


Fig. 490A.—Installation arrangement of stage switchboard and magazine panel as recommended by the *Mutual Electric & Machine Co.* (The cables from the general-lighting cabinet usually run to the main-house and main-stage switches from whence the current is then conducted through busbars to the magazine switches, then through the wiring channel to the dimmers and from there to the magazine panel or direct to the circuits controlled.)

the house and stage lights. This may involve a change in the color of the light. Also, the design should be such that he can gradually change the brightness of any combination of any house or stage lights by using the dimmers.

419. The Location Of The Stage Switchboard is usually at the right-hand side of the proscenium arch when standing on the stage facing the audience (see Fig. 531). The reason for such location is that most of the portable lighting equipment that is carried by travelling companies is made "right-handed." That is, when the portable equipment is placed on the stage facing the audience, the leads connecting to it are

on its right-hand side. In some theatres, the stage switchboard is, because of space or other limitations, installed at the left-hand side of the proscenium. This location is the exception rather than the rule.

420. Theatre Stage Switchboards May Be Either "Live Front" Or "Dead Front." However since the CODE (Rule 38*c*) now prohibits the installation of live-front stage switchboards, it is not probable that they will ever again be used in this country. Therefore, the following material in this book will treat exclusively of dead-front switchboards.

NOTE.—THE STAGE SWITCHBOARD FOR SMALL MOVING PICTURE HOUSES MAY SOMETIMES BE A LIVE-FRONT BOARD PROVIDED IT IS ENCLOSED IN A STEEL CABINET. The following paragraph, by H. S. Wynkoop, Chief Electrical Inspector, New York City, which explains the practice in New York City, probably exemplifies the practice of electrical inspection bureaus of other cities:

"Literally, the CODE requires dead-front switchboards for moving picture establishments, even if there is no stage. We draw a distinction, however, between such a house and one which has movable borders, footlights, proscenium side-strips, stage pockets and other facilities for staging a regular dramatic or operatic performance. In the mere picture house, with its footlights and lights outlining the proscenium arch, there is no point in calling for a dead-front switchboard; and in fact the switchboard reduces itself to a simple panel inclosed in a cabinet. A third class of house with which we have to deal includes *lecture halls* and *school auditoriums.* If the stages of these rooms are equipped for the giving of operatic or dramatic shows, we class them as theatres; but if, as is usually the case, they are not so equipped, and are used a few times a year for amateur theatricals, additional and temporary wiring is permitted under close supervision, and this wiring is taken from the panel board."

421. Stage Switchboards May Be Either of The Manual Type Or Of The Remote-control Type. *A manual switchboard* is one, the lighting switches of which are mounted directly on or behind the board itself, and operated directly by the hand. *A remote-control switchboard* is one, the lighting switches—remote-controlled switches, Div. 8—of which are located in a convenient place remote from the control switchboard—pilot board—and which are operated therefrom electrically by suitable control switches—pilot switches—which are mounted on the pilot board.

Note.—*Theoretically, Remote-control Switchboards May be Remotely Controlled Either Mechanically or Electrically.* In a mechanical remote-control board, the lighting-circuit switches would be located at some point distant from the control board itself and operated therefrom, through a system of links and levers, just as is done (Sec. 315) for mechanical remote control of power and lighting switchboards. The ease and flexibility of control, which is provided by the electrically-operated remote control board would not be possible with a mechanically operated one.

422. Manually-operated Dead-front Stage Switchboards May Be Classified According To Construction as: (1) *Non-*

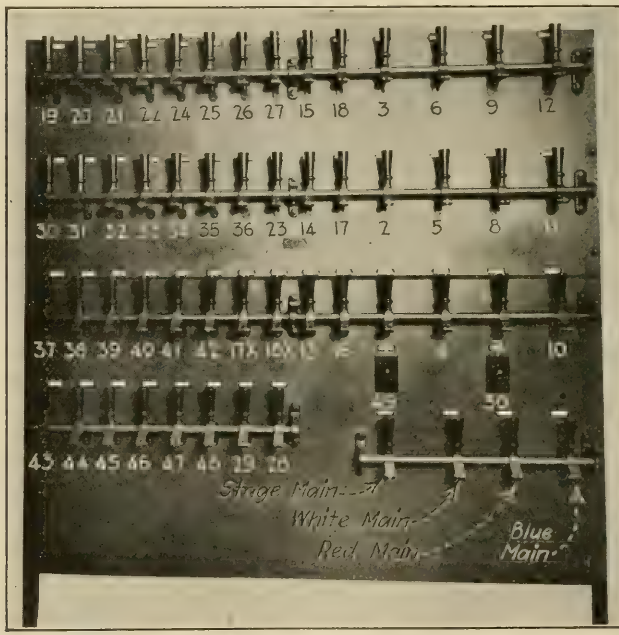


Fig. 491.—Front view of non-interlocking, dead-front manually-operated stage switchboard. (Mfr'd. by *The Trumbull Electric Mfg. Co.* for the Beacham Theatre, Orlando, Fla.)

interlocking. (2) *Interlocking.* A non-interlocking board is one wherein each individual switch must be operated separately and independently of every other switch on the board. However, a board of this type is usually so wired (Sec. 423) that the lamps which are controlled by a number of magazine switches (*M*, Fig. 489) may be simultaneously lighted or

extinguished by a "main" switch (W, R or B, Fig. 489). An interlocking board is one wherein the various magazine switches (M, Fig. 489) may be mechanically interlocked to a shaft. Then, upon operating this shaft by means of a master lever, those magazine switches which have been interlocked therewith, may be simultaneously opened or closed. Thus, those lamp-groups which are controlled by the magazine switches that have been so interlocked may be simultaneously lighted or extinguished. The mechanical construction of

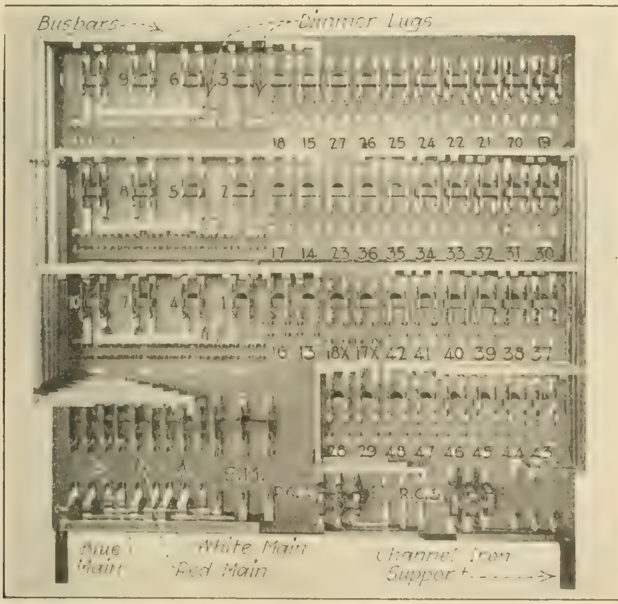
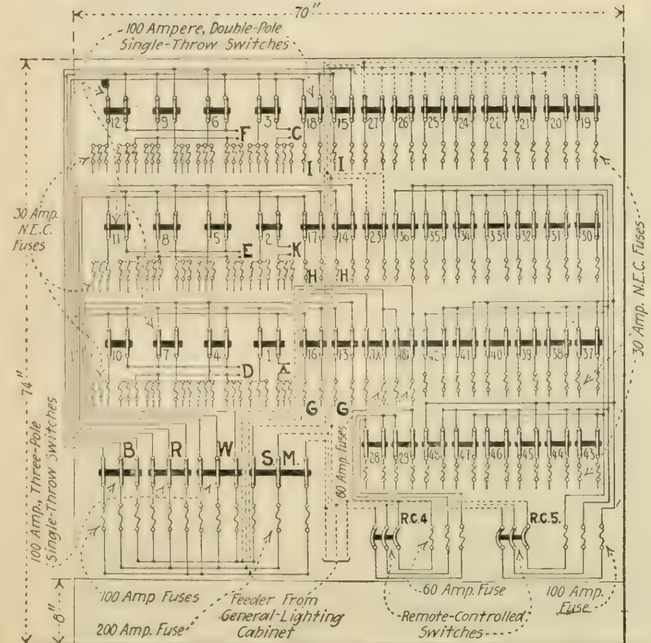


FIG. 492.—Rear view of non-interlocking, dead-front, manually-operated stage switchboard. (Mfr'd. by *The Trumbull Electric Mfg. Co.* for the Beacham Theatre, Orlando, Fla.)

switches and operating mechanisms which are used on certain dead-front manually-operated switchboards is explained and illustrated in Sec. 427.

423. A Typical Non-interlocking, Dead-front, Manually-operated Stage Switchboard is shown in Figs. 491 and 492. The wiring diagram and schedule of connections is shown in Fig. 493. The dimmers, which are mounted above the switchboard, are not shown.



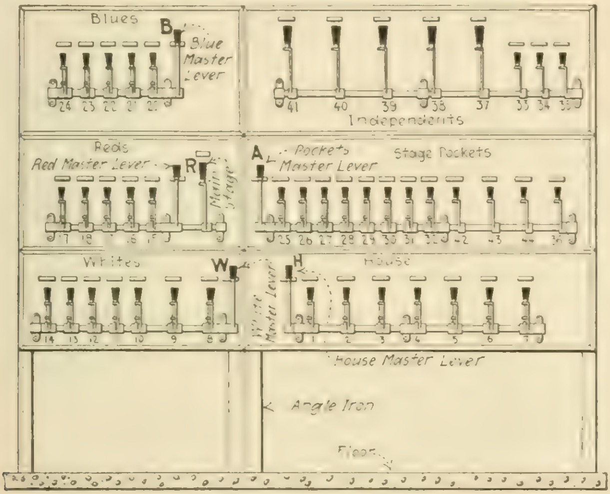
SCHEDULE

DIMMER	Controls	DIMMER	Controls
A	White Foot Lights	F	Blue Borders
K	Red Foot Lights	G	Stage Pockets
C	Blue Foot Lights	H	Stage Pockets
D	White Borders	I	Stage Pockets
E	Red Borders		

SWITCH NO.	Controls	SWITCH NO.	Controls
1	White Foot Lights	27	Orchestra Plug Outlets
2	Red Foot Lights	28	Wall Fan Outlets
3	Blue Foot Lights	29	" " "
4	White Borders	30	Bracket Outlet In Auditorium
5	Red Borders	31	" " " "
6	Blue Borders	32	Ceiling Outlets " "
7	White Borders	33	" " " "
8	Red Borders	34	" " " "
9	Blue Borders	35	" " " "
10	White Borders	36	" " " "
11	Red Borders	37	" " " "
12	Blue Borders	38	" " " "
13	Stage Pockets, Incandescent	39	" " " "
14	" " " "	40	Spare Circuit
15	" " " "	41	" "
16	" " " "	42	" "
17	" " " "	43	" "
18	" " " "	44	" "
17-X	Stage Pockets, Arcs "	45	" "
18-X	" " " "	46	" "
19	Dressing Rooms, Halls And Toilets	47	" "
20	" " " " "	48	" "
21	" " " " "	49	Momentary Contact Switch Controlling R.C. No.9
22	" " " " "	50	" " " " R.C. No.5
23	Ceiling Outlets Above Gridiron	R.C.4	Fan Main
24	Bracket Outlets Rear Of Stage	R.C.5	House Main
25	" " Fly Gallery	S.M.	Stage Main
26	Orchestra Plug Outlets		

Fig. 493.—Wiring diagram of non-interlocking, dead-front manually-operated stage switchboard. Full lines indicate busbars. Dotted lines indicate rubber-covered copper conductors. (Mfr'd. by *The Trumbull Electric Mfg. Co.* for The Beacham Theatre, Orlando, Fla.)

424. An Interlocking, Dead-front, Manually-operated Stage Switchboard is shown in Figs. 494, 495, and 496. The switchboard wiring diagram is shown in Fig. 497. As indicated in Fig. 497, the stage lights that are controlled by



SCHEDULE

Switch No.	CONTROLS	Switch No.	CONTROLS	Switch No.	CONTROLS
1	Main Ceiling No. 1	16	Red Border No. 1	31	Stage Pockets
2	" " " 2	17	" " No. 2	32	" "
3	Orchestra Ceiling	18	" " No. 3	33	Orchestra Plugs
4	" Walls	19	" " No. 4	34	" "
5	Balcony "	20	Blue Foots	35	Stage Chandelier
6	Box "	21	" Border No. 1	36	Balcony
7	" Ceilings	22	" " No. 2	37	Picture Booth
8	Tormentor	23	" " No. 3	38	Stage Wall Cabinet
9	White Foots	24	" " No. 4	39	Fly Gallery
10	White Border No. 1	25	Stage Pockets	40	For Future Use
11	" " No. 2	26	" "	41	" " "
12	" " No. 3	27	" "	42	" " "
13	" " No. 4	28	" "	43	" " "
14	Procenium Strip	29	" "	44	" " "
15	Red Foots	30	" "	45	Main Stage

FIG. 494.—Front view of interlocking, dead-front, manually-operated stage switchboard. (Manufactured by the *Pringle Electrical Mfg. Co.* for the Hippodrome Theatre, Buffalo, N. Y.)

switches Nos. 8 to 24, inclusive, may be extinguished by opening the stage-main switch, No. 45. That is, switch No. 45 controls all of the switches Nos. 8 to 24, inclusive. Any or all of the switches No. 20 to 24 which control the blue stage

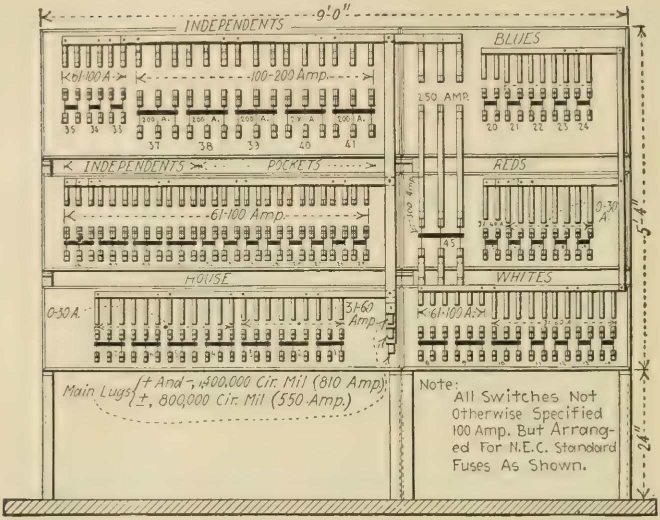


FIG. 495.—Rear view of interlocking, dead-front, manually operated stage switchboard showing dimensions, fuse and switch sizes. (Manufactured by *The Pringle Electrical Mfg. Co.* for the Hippodrome Theatre, Buffalo, N. Y.)

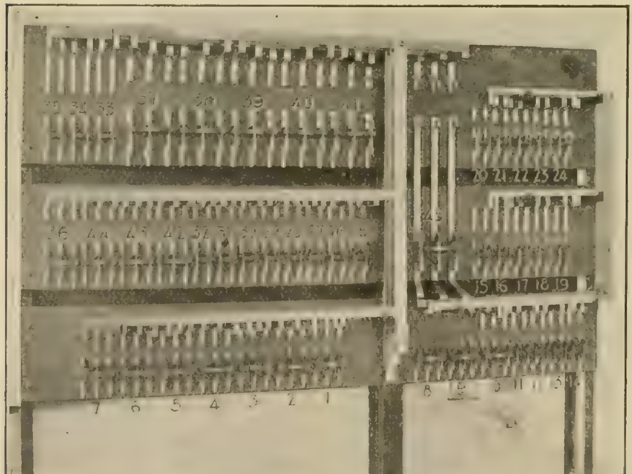


FIG. 496.—Rear view of interlocking, dead-front, manually-operated stage switchboard showing busbar construction. (Manufactured by *The Pringle Electrical Mfg. Co.* for the Hippodrome Theatre, Buffalo, N. Y.)

lights, may be simultaneously opened or closed by interlocking them on the shaft and then operating the blue master lever, *B* (Fig. 494). Similarly, the red stage lights, the white stage lights, the stage-pockets, and the house lights may be controlled, respectively, by their master levers, *R*, *W*, *A* and *H*, Fig. 494. No master handle is provided for the independents—switches Nos. 33 to 44, inclusive; consequently, to light or extinguish the lamps which are controlled by these switches, each switch must be individually and separately operated.

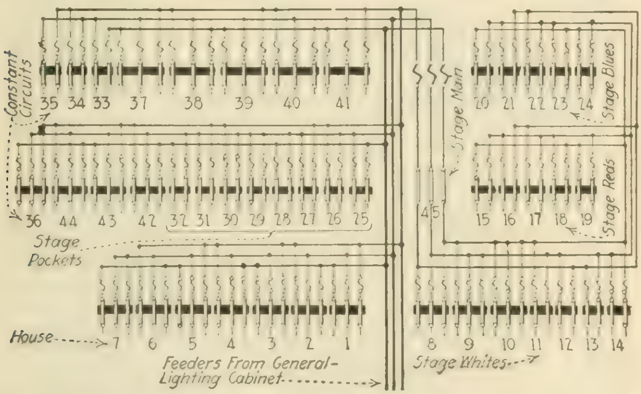


FIG. 497.—Wiring diagram of interlocking, dead-front, manually-operated stage switchboard. (Manufactured by *The Pringle Electrical Mfg. Co.* for the Hippodrome Theatre, Buffalo, N. Y.)

NOTE.—A SIMILARITY IN THE CONTROLS WHICH ARE PROVIDED BY THE NON-INTERLOCKING SWITCHBOARDS may be noted by a comparison of the wiring diagram of Fig. 493 and the front view of Fig. 494. That is, the white main, *W*, Fig. 493, and the master lever, *W*, Fig. 494, control the stage white lights. The red main, *R*, Fig. 493, and the master lever, *R*, Fig. 494, control the stage red lights. The blue main, *B*, Fig. 493, and the master lever, *B*, Fig. 494, control the stage blue lights. Switch *SM*, Fig. 493, and switch No. 45, Fig. 494, control all stage lights. Switch *RC* 5 (Fig. 493) and master lever *H* (Fig. 494) control the house lights. Switches Nos. 19 to 27, inclusive, (Fig. 493) correspond to the independents—switches 33 to 44—of Fig. 494. Hence, from the above comparison, it is seen that essentially the same control is provided by the electrical connections of Fig. 493 as that which is provided by the mechanical interlocking mechanism of Fig. 494.

425. An Interlocking, Manually-operated Stage Switchboard Which Is Provided With A Grand-master Lever is

shown in Fig. 498. The wiring diagram and the control schedule for this switchboard are shown in Figs. 499 and 500. Any or all switches in each horizontal row of magazine switches (Fig. 498) may be interlocked so that they can be operated by their respective master levers, *W*, *B*, *R* or *H*, for that row.

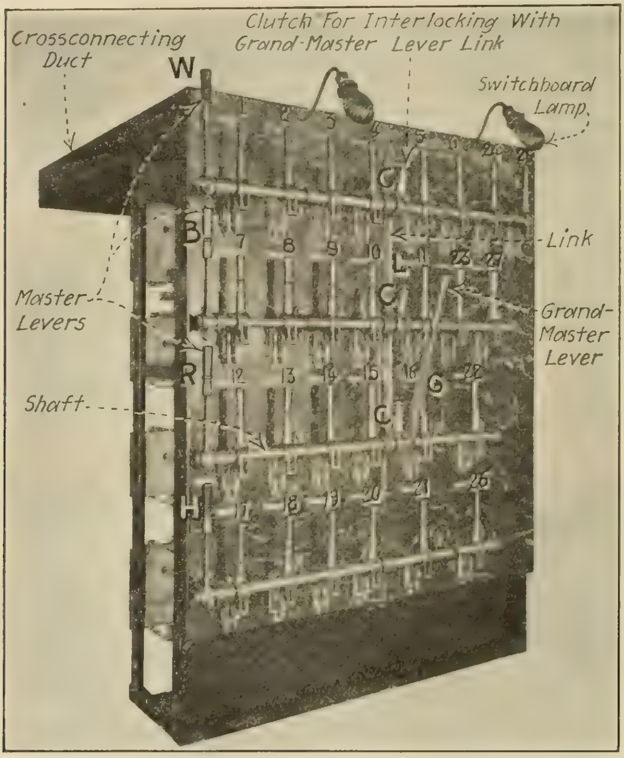


FIG. 498.—Interlocking dead front switchboard for Bay Ridge Theatre, Brooklyn, N. Y., provided with master and grand master levers. (*Sprague Electric Works.*)

Furthermore, the clutches *C*, may be so set that either one or all of the three upper horizontal shafts will be interlocked with the link, *L*. Then, by operating the grand-master lever, *G*, those magazine switches which are so interlocked to the horizontal shafts may be either opened or closed.

EXAMPLE.—Assume that a scene opens with the white foots, and white left and right prosceniums, white border No. 1, blue borders Nos. 2 and 3, and red border No. 4. At a certain cue all stage lights are to be extinguished except the white foots and white border No. 1. The stage electrician locks all three clutches, C, to the link, L. He then interlocks magazine switches (Figs. 498 and 500) Nos. 1, 9, 10 and 16 with their respective shafts. Then upon receiving the cue, he pulls the grand-

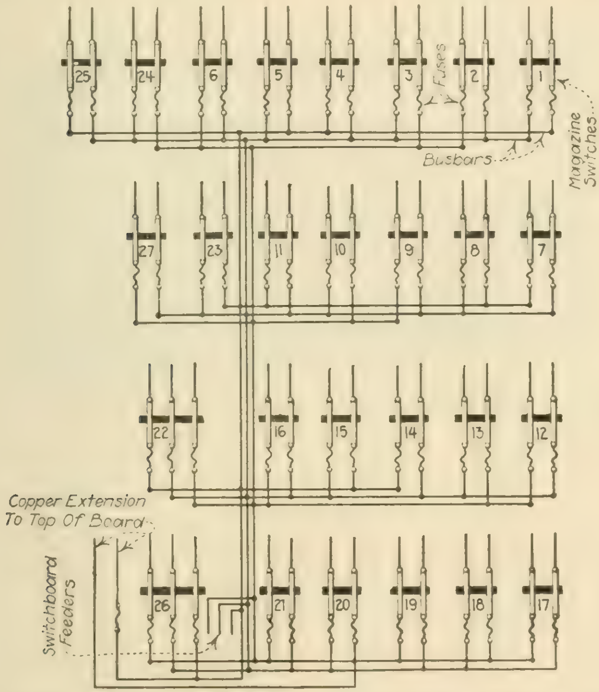


FIG. 499.—Rear view wiring diagram of interlocking stage switchboard (Manufactured by *The Sprague Electric Works* for Bay Ridge Theatre, Brooklyn, N. Y.)

master lever, G. This extinguishes the left and right prosceniums, blue borders Nos. 2 and 3, and red border No. 4, leaving only the white foots and white border No. 1 lighted.

426. A Manually-operated, Interlocking Stage Switchboard Provided With Pre-set Master Levers is shown in Fig. 501. As indicated in Fig. 501, this switchboard is also provided with a grand-master lever. Each horizontal shaft consists of a "shaft within a shaft." The mechanism is so constructed

that the magazine switches, M, may be interlocked with either of these shafts. Master lever A operates one shaft, and master lever B operates the other shaft. Hence, three of the magazine switches, M, may be interlocked with the shaft which is operated by A, and the other three switches between A and B may be interlocked with the shaft which is operated by B. Then, by simultaneously pulling downward on A and pushing

Switch Number	Number Of Poles	Switch Capacity	Fuse Capacity	Lug Size	Controls
1	2	100	10	12	Pros. L. & R.
2	2	100	35	8	White Foots.
3	2	100	35	8	" Border No. 1
4	2	100	35	8	" " No 2
5	2	100	35	8	" " No 3
6	2	100	35	8	" " No 4
7	2	100	12	12	Blue Foots.
8	2	100	12	12	" Border No. 1
9	2	100	12	12	" " No 2
10	2	100	12	12	" " No. 3
11	2	100	12	12	" " No 4
12	2	100	12	12	Red Foots
13	2	100	12	12	" Border No 1
14	2	100	12	12	" " No 2
15	2	100	12	12	" " No. 3
16	2	100	12	12	" " No 4
17	2	100	10	12	Sidelights
18	2	100	10	12	Boxes L & R.
19	2	100	35	8	Main Chandelier
20	2	100	25	10	Orch. & Balc. Ceil.
21	2	100	20	12	Fans
22	3	100	75	3	Inc. Pockets
23	2	100	10	12	Musicians
24	2	100	70	4	Work Panel
25	2	100	50	6	Dres. Room Panel
26	3	200	175	000	Arc Pockets
27	2	100	35	8	Stage Chandelier

Fig. 500.—Control schedule for stage switchboard in Bay Ridge Theatre, Brooklyn, N. Y. (*Sprague Electric Works.*)

upward on B, any of the switches may be closed and the remainder of the switches opened at the same time. Thus, with a board of this type, it is sometimes possible for the switchboard operator to so pre-set the switches that a lighting change can be instantly effected by operating one or more of the master levers. Furthermore, this switchboard is provided

with a grand-master lever, which operates the same shafts as those which are operated by the master levers, *B*. Thus, by interlocking switches *M* with the shaft which is operated by *B*, the grand-master lever may be used to simultaneously open or close any desired number of magazine switches in two or more horizontal rows.

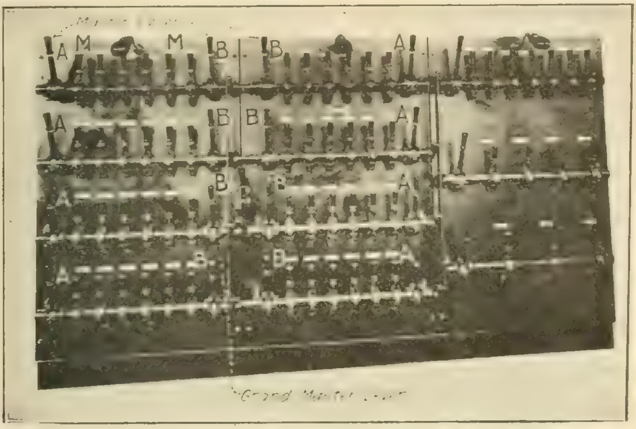


FIG. 501.—Interlocking, dead-front, manually-operated stage switchboard provided with grand-master lever and "Pre-set" master levers. (*Metropolitan Electric Mfg. Co.*)

NOTE.—THE RELATIVE LOCATION OF THE DIMMERS, SWITCHBOARD AND MAGAZINE PANEL FOR A TYPICAL MANUALLY-OPERATED STAGE-SWITCHBOARD INSTALLATION is shown in Fig. 502. The dimmer bank is usually mounted above the switchboard. In large installations where sufficient space is available, the dimmer bank is sometimes located at the side of the stage switchboard. The magazine panel is located in rear of the switchboard. Sufficient space must be provided between the switch board and magazine panel so that fuse replacements may be readily made. The sheet-steel *cross-connecting duct, D*, sometimes called a *tangle-box raceway, pull box* or merely *raceway* is located directly behind the top of the switchboard and bridges the space between the board and the top of the magazine cabinet. The function of the cross-connecting duct is to provide a single metal raceway for all of the conductors which run from lighting-circuit switches on the switchboard to the magazine-panel cabinet.

426A. A Manually-operated Pre-set Dead-front Stage Switchboard is illustrated in Fig. 502A. The pre-selective feature (Sec. 430) is provided by the construction of the

magazine-switch lever mechanism (Fig. 502B). Switchboards of this type are regularly manufactured with any

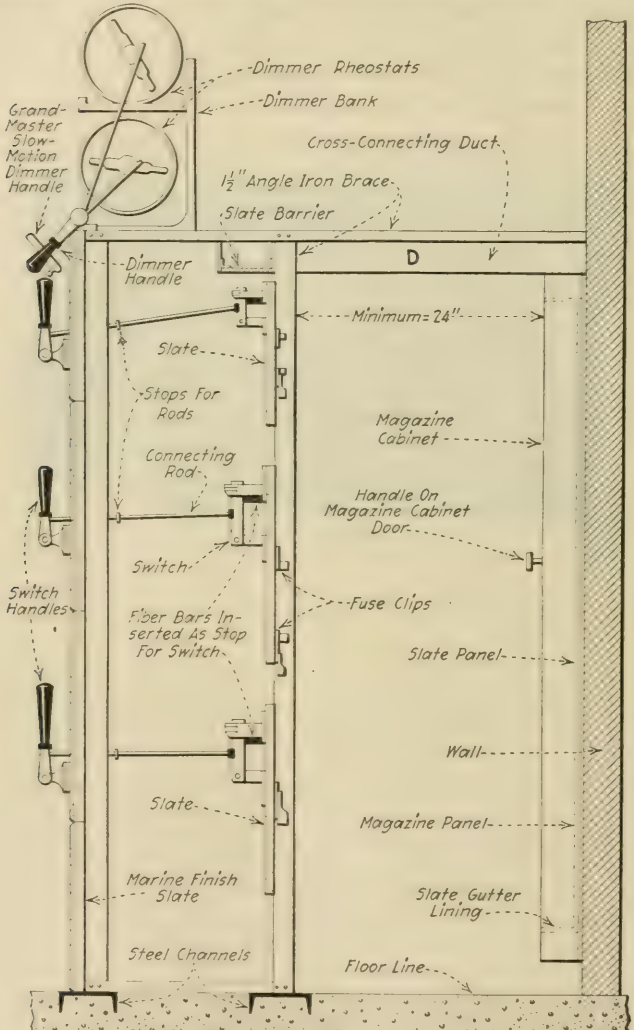


FIG. 502.—End view of manually operated stage switchboard showing relative positions of switchboard, dimmers, and magazine panel. (*Electrical Mfg. Co.*)

desired number of switches arranged, usually, in three or four horizontal rows. When so constructed, they may be

equipped with a grand master lever which may be operated to control any of the magazine switches on the switchboard. The principle of operation of such a switchboard is explained below.

NOTE.—THE OPERATION OF THE MANUALLY-OPERATED PRE-SELECTIVE STAGE SWITCHBOARD (Figs. 502A and 502C) is, briefly, as follows: The bearing casting, *B*, Fig. 502B, is rigidly fastened to the shaft *S*, so that operation of the master lever (*M*, Fig. 502A) rotates the bearing

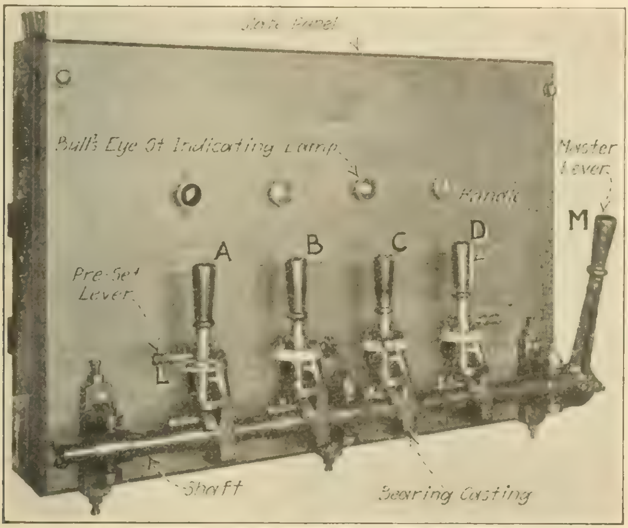


FIG. 502A.—Four switch levers of a manually-operated pre-selective stage switchboard. The pre-set lever (*L*, Fig. 502B) is shown in the four different positions. (***Mutual Electric & Machine Co., Detroit, Mich.***)

casting of each magazine switch on the shaft, whereby the switch may be opened, closed or not moved depending on the position of the pre-set lever. The magazine switch handle is connected by a link to the switch by an arrangement similar to that shown in Fig. 504. The pre-set lever, *L*, Fig. 502B, has four positions: (1) *Off.* (2) *Positive.* (3) *On.* (4) *Independent.* When the pre-set lever *L*, is in the *Off* position (*A*, Fig. 502A), operating the master lever downward will open switch *A*, but operating it upward will not close *A*. With the pre-set lever in the *On* position (*B*, Fig. 502A) operating the master lever upward will close switch *B*, but operating it downward will not open *B*. With the pre-set lever in the *Pos* (positive) position (*C*, Fig. 502A), operating the master lever downward will open *C* and operating it upward will close *C*. If the pre-set lever is in the *Ind* (independent) position (*D*,

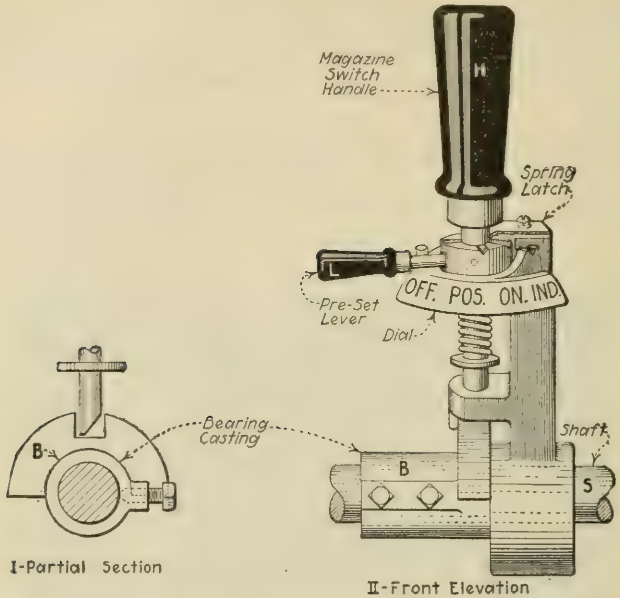


Fig. 502B.—Magazine switch lever mechanism of a manually-operated pre-selective stage switchboard. (*Mutual Electric & Machine Co., Detroit, Mich.*)

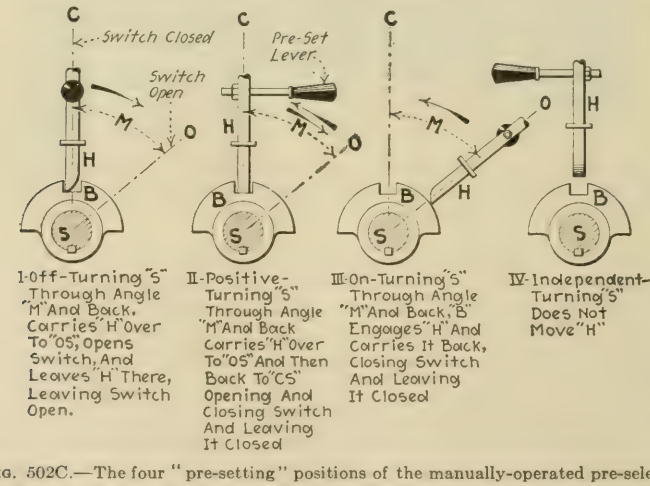


Fig. 502C.—The four "pre-setting" positions of the manually-operated pre-selective switchboard. (In effect, *H* is connected, by a link, to the switch about as shown in Fig. 504. With the pre-set lever in the *off* position as shown at *I*, further operation of *S* by the master lever (*M*, Fig. 502A) will not move the switch after it is closed. Similarly, with the pre-set lever in the *on* position (*III*) after the switch is closed by *S*, further operation of *S* will not open the switch.)

Fig. 502A), switch *D* cannot be opened or closed by operating *M*. The switchboard operator pre-sets for a scene as follows: The pre-set levers of those magazine switches that control the lamp groups which are to remain either lighted or extinguished for the next scene are placed in the *Ind* position. The pre-set levers of those magazine switches that control lamp-groups which are not then lighted but which are to be lighted for the next scene are set in the *On* position. The pre-set levers of those magazine switches that control lamp-groups which are then lighted but which are to be extinguished for the next scene are set in the *Off* position. Then, when the cue for the next scene is received, the switchboard operator moves the master lever downward and then upward. This provides, almost instantaneously, the desired lighting effect for that scene.

427. Some Of The Various Types Of Switches Which Are Employed In Dead-front Manually Operated Stage Switchboards are shown in Figs. 503, 504, 505 and 506. The

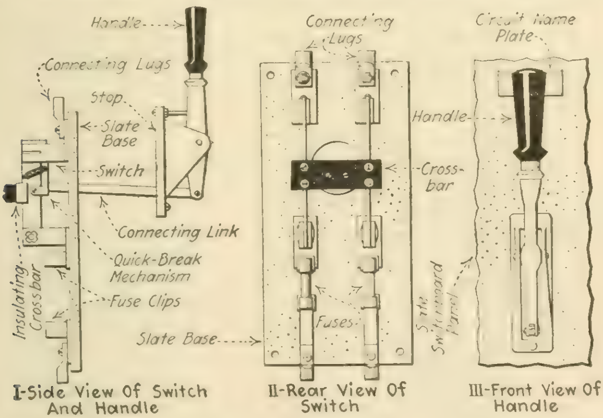


FIG. 503.—Manually-operated switch for a dead-front stage switchboard. (*Metropolitan Electric Mfg. Co.*)

switches shown in Figs. 503 and 506 are provided with a quick-break mechanism. The switch illustrated in Figs. 504 and 505 has a double break-jaw and no hinge-jaw. The fuses, which are carried on the back of the switch form a part of the switch blades.

NOTE.—THE RATING OF THE MAGAZINE SWITCHES ON A MANUALLY-OPERATED STAGE SWITCHBOARD is seldom less than 60 amp. Switches which have a rating of 100 amp. are frequently used, even though the connected load requires a current much smaller than 100 amp. This is to insure mechanical strength and ruggedness. However,

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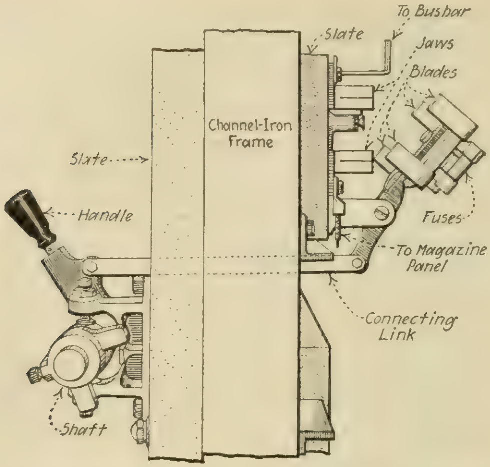


FIG. 504.—Showing arrangement of the switch and handle for a dead-front manually-operated switchboard. (*Mutual Electric & Machine Co.*)

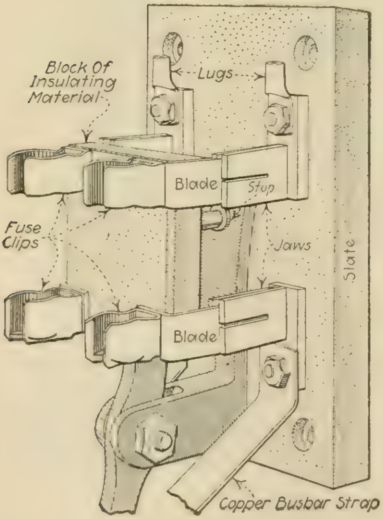


FIG. 505.

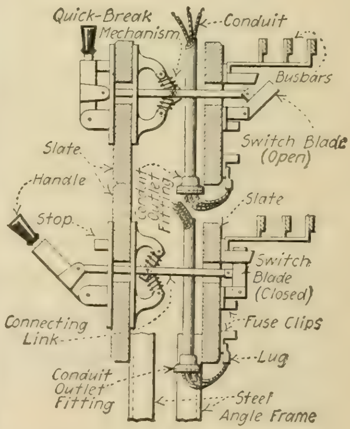


FIG. 506.

FIG. 505.—Closed position of double-pole magazine switch for a dead-front, manually-operated switchboard. (*Mutual Electric & Machine Co.*)

FIG. 506.—Showing quick-break switch for manually-operated dead-front stage witchboard. (*Pringle Electrical Mfg. Co.*)

they may be fused (Sec. 449) with as small-sized fuses as the magazine sub-feeders will permit (Sec. 169).

428. One Principal Type Of Remote-control Stage Switchboard is known as *The Major Pre-selection System Of Remote Control.* It was invented by *R. E. Major* of the *Major Equipment Co.,* 2518 Cullom Ave., Chicago, Ill. It is manufactured and sold by the *Frank Adam Electric Co., St. Louis, Mo.* The advantages of this system of theatre lighting-control, the description of the various elements and the circuits of this switchboard are discussed in the following sections.

429. The Advantages Of The Major Pre-selection Control System are: (1) *Pre-selective features and maximum flexibility of control which can not be obtained with the manual control system are provided.* (2) *Simple to operate.* (3) *An extremely safe apparatus as regards both personal injury and fire hazards.* (4) *It is made up of a number of standardized unit elements.* (5) *It occupies a minimum of stage-floor space.* How the above-advantages are obtained will be understood by a study of the subsequent material.

430. By "Pre-selective" Control is meant the control where by the stage electrician can select *in advance* the lamp-groups, which he desires to have lighted or extinguished simultaneously for the next lighting effect. This he may do without interfering with the lighting effect then in use. The pilot switches which control these groups, having been "set-up," he can instantly light all of them together by operating the master pilot switch. The pre-selective control is obtained by a certain method of interconnection of the pilot switches with the remote control switches. This general method of interconnection is described in following sections.

Example.—The Pre-selective Features And The Flexibility Of Control Which Is Provided By The Major System is illustrated by the following simple lighting-effect changes. The stage is assumed to be dark; that is, no stage lamps are lighted. At a certain signal the white foots, white border No. 2 and red border No. 1 are to be lighted. The switchboard operator places, in advance of the signal, the proper pilot-switch handles in the set-up position. Then, when the signal is received, he gives the proper master pilot switch a light tap with his hand. This simultaneously lights all of the lamps mentioned above. The second lighting effect is to be provided by the white foots, the red prosceniums

and the blue border No. 4. He again places, in advance, the proper pilot switches in the set-up position. This he may do without disturbing the lighting-effect then in use. Then when he receives the signal for the second lighting effect, he gives the two master pilot-switch handles a light tap with his hand; whereupon the lighting-effect which is provided by the white foots, white border No. 2, and red border No. 1 is instantly and

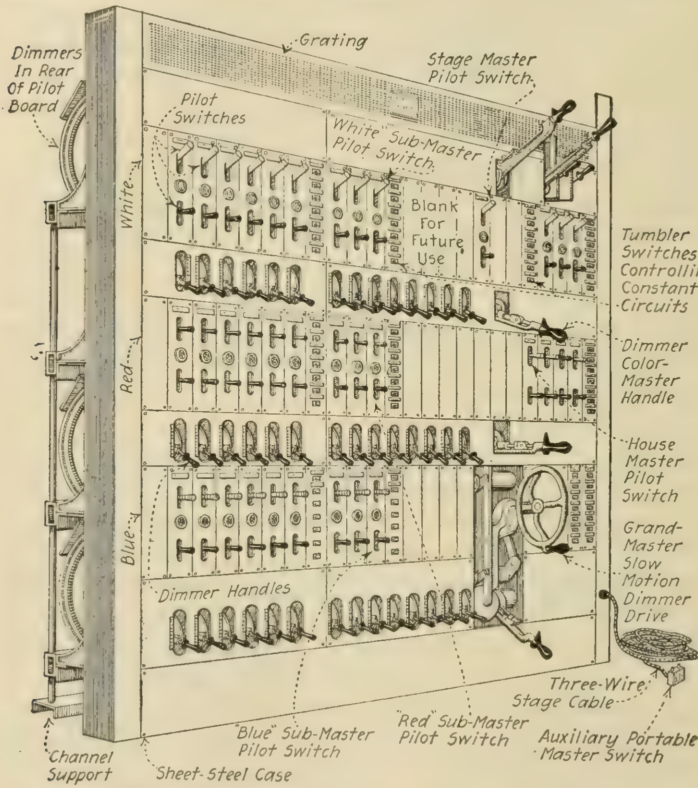


FIG. 507.—Major combination dimmer and pilot board. (Manufactured by *The Frank Adam Electric Co.*)

simultaneously changed to that which is provided by the white foots, red prosceniums and blue border No. 4. How the operating circuits are controlled, by the pilot and the remote-controlled switches, and the circuit arrangements which are necessary to produce these lighting changes are explained and shown in Sec. 435.

431. The Major Pre-selection System Of Remote Control Comprises Two Essential Elements: (1) *A pilot board* (Sec.

416 and Fig. 507) which consists of the desired number of pilot switches (Sec. 416), and which is located (Fig. 531) on the stage. (2) *A remote board* (Sec. 416 and Fig. 508) which

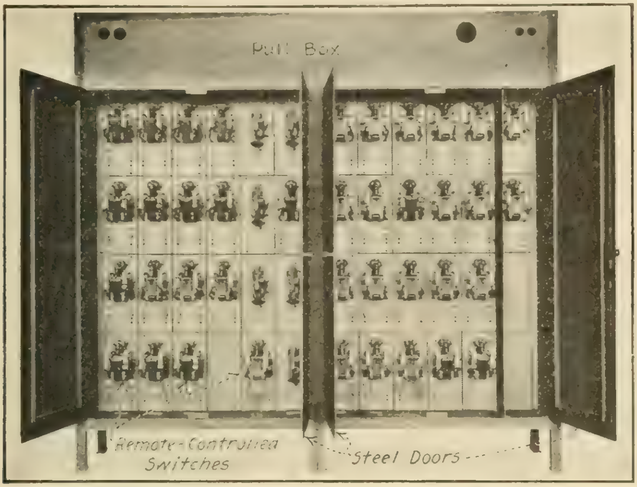


Fig. 508.—Major remote board installed in Sheridan Park Theatre, New York City. (Manufactured by *Frank Adam Electric Co.*)

is usually located (Fig. 530) below the stage or elsewhere, preferably near the load center. The individual pilot switches (Sec. 432) on the pilot board serve the same purpose as do the

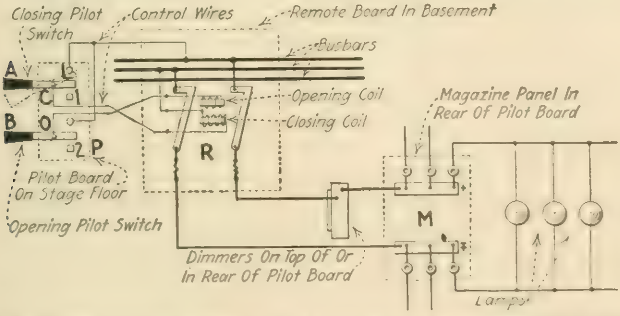


Fig. 509.—Diagrammatic arrangement of a pilot switch, a remote controlled switch and the magazine circuit which is controlled thereby.

momentary-contact switches (Div. 8) which are used to control any remote-controlled switch. The remote-controlled switches (Sec. 323) on the remote board are, in reality, merely

remote-controlled magazine switches (Sec. 416). That is, when a pilot switch (*P*, Fig. 509) is operated, the control circuit of the remote-controlled switch, *R*, is closed. This either opens or closes the remote-controlled switch (Sec. 323), thereby lighting or extinguishing those lamps which are connected to the magazine panel, *M*, controlled by that switch.

Note.—The Major Pre-selection System Of Remote-controlled Stage Switchboard will hereinafter be referred to as *the Major System.*

Note.—In The Major System, The Dimmers May Be Mounted In The Rear Of Or On Top Of The Pilot Board. When the dimmers are mounted in rear of the pilot board (Fig. 507), they are so arranged that each dimmer handle projects through the front side of the board directly below the pilot-switch handle that controls the circuit which contains that dimmer. When the dimmers are mounted above the pilot board, the arrangement is similar to that indicated in Fig. 502 for a manually-operated board.

Note.—The Remote-controlled Switch Which Is Used In Connection With The Major System is shown in Fig. 394. Its operation is described in Sec. 323.

432. The Major Pilot Switch Unit (Figs. 510 and 511) consists of two single-pole double-throw switches (*A*, and *B*, Fig. 511-*II*) mounted on a thermoplax (moulded-asbestos compound) base as shown in Fig. 510. Its operation is explained below.

Explanation.—Both switches (*A* and *B*, Fig. 511) are identical in construction. Each switch is held in the open position by a spring (*S*, Fig. 511-*I*). When either handle, *H* is pressed downward, as shown in Fig. 510, the contact block, *D*, touches the laminated-copper contact, *E*. This is called the *momentary position* (Fig. 512-*I*) because as soon as the pressure on the handle is removed, the spring (*S*, Fig. 511-*I*) causes the switch to return to the open position. When either handle is pulled upward as shown at *HB* in Fig. 510, the blade (*F*, Fig. 511) contacts with the jaw, *J*. The friction between the jaw and the blade holds the switch in this position until the switch handle is pushed downward by hand. This is called the *set-up position* (Fig. 512-*II*).

The thermoplax base is provided with an indicating lamp, (*P*, Fig. 511-*II*). The indicating-lamp terminals (*M* and *N*) are connected to the lamp-receptacle as indicated at *R*, Fig. 511-*III*. The lamp, *P*, is so connected (Sec. 443) that it is illuminated when the lamp-group which is controlled by the switch on which the lamp is mounted is lighted, and extinguished when the lamp-group is extinguished.

When several pilot-switch units (Fig. 510) are mounted on the supporting frame, as in Fig. 507, the metal guard or front plate (*M*, Fig. 510) of

each switch protects all live parts of the board from contact from the front. Thus, the pilot board is (CODE Rule 38c) a dead-front board.

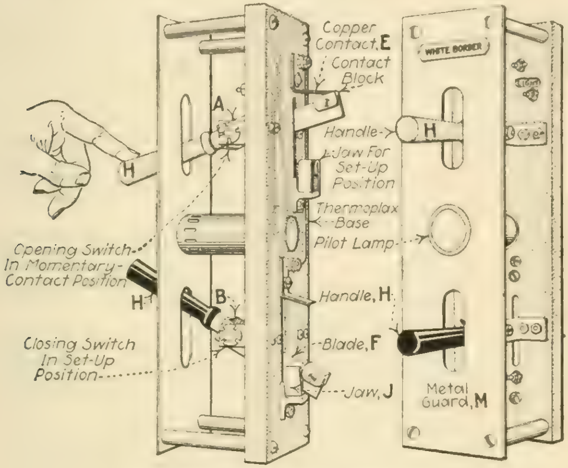


FIG. 510.—*Major* pilot switch unit.

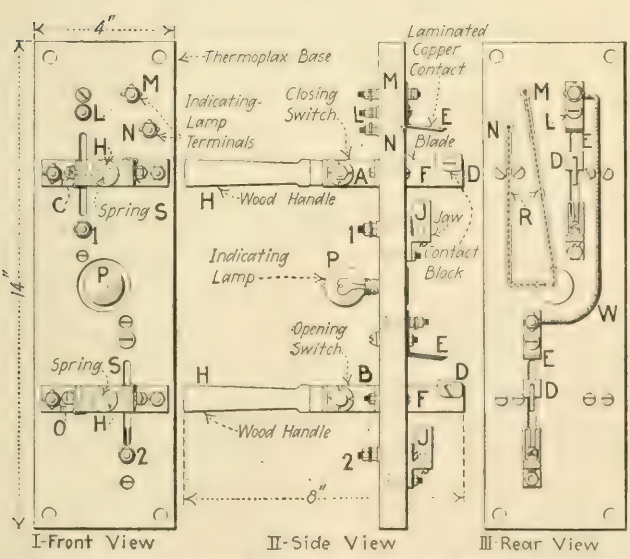


FIG. 511.—The *Major* pilot switch. (Manufactured by *Frank Adam Electric Co.*)

A wire (*W*, Fig. 511-*III*) provides a permanent electrical connection between the laminated copper contact of switch *A* and that of switch *B*.

Thus, when switch A is closed to the momentary position, an electrical connection is made between terminals L and C (Fig. 511-*I*). When switch A is closed to the set-up position, electrical connection is made between terminals C and 1. When switch B is closed to the momentary position, electrical connection is made between terminals L and O. When B is closed to the set-up position, electrical connection is made between terminals O and 2.

Note.—The Symbolical Wiring Diagram Of A Pilot Switch is shown in Fig. 512.

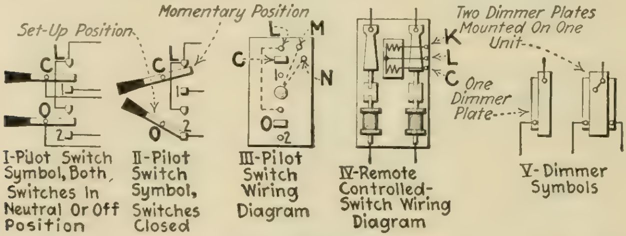


Fig. 512.—Wiring diagrams and symbols of pilot switch, and wiring diagram of remote-controlled switch and dimmers for the *Major* system of remote control. (For remote-controlled switch symbol, see Fig. 513.)

433. The Circuit Diagram Of The Major System For A Single Lamp-group is shown in Fig. 509. Switch A (Figs. 509 and 511) is called the *closing switch*. This is because the connections are so made that it operates to close the remote-controlled switch, R. Switch B (Figs. 509 and 511) is called the *opening switch*. This is because it operates to open the remote-controlled switch. When switch A (Fig. 509) is closed to the momentary position (dotted position) the closing coil of R is energized (see Sec. 323) and R closes. This lights the lamps. When B is closed to the momentary position, the opening, coil of R is energized, and R opens. This extinguishes the lamps. The circuits may be traced out by referring to Fig. 509. The pilot switches are so mounted on the pilot board and are so connected to the remote-controlled switches that the upper row of handles (Fig. 507) in any horizontal row of pilot switches contains the opening-switch handles. Consequently the lower row of handles in any horizontal row contains the closing-switch handles. All opening pilot switch handles are painted black. All closing pilot switch handles are painted to correspond to the color of the lamps which they control, as red, white or blue.

Explanation.—The elementary arrangement shown in Fig. 509, which consists of only one pilot switch, one remote-controlled switch and one lamp-group, is never used in the Major system. However, by a careful study of the circuits shown therein, and of the operation of the pilot switch (Sec. 432) the following descriptions of the preselective features and of the flexibility of control which are provided by this system will be readily understood.

434. One Pilot Switch May Be So Connected That It Will Control Two Or More Other Pilot Switches as indicated in Figs. 513 and 514. Switch No. 1 (Figs. 513 and 514) is, as explained below, so connected that it will control the group of

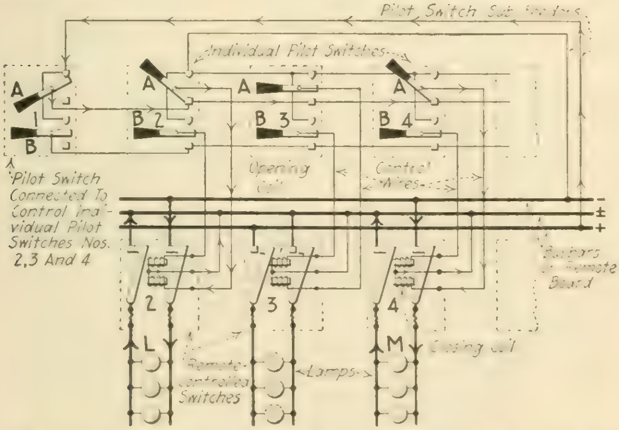


Fig. 513.—One pilot switch so connected as to control two, or more; other pilot switches. (The set-up and the current path is shown for lighting lamp-groups L and M.)

individual pilot switches Nos. 2, 3 and 4. Hence, it is (Sec. 416) a *sub-master pilot switch.* This arrangement is nearly always employed on major theatre switchboards. Also such an arrangement of connections is, when there are only a few lamp-groups in the house, sometimes used to control the house lights. Then, switch No. 1 (Figs. 513 and 514) is called the *house master pilot switch,* or the *house main.*

Explanation.—Note that the connections which are shown in Fig. 513 are identical to those which are shown in Fig. 514. The individual pilot switches, Nos. 2, 3 and 4 (Figs. 513 and 514), are so connected (Sec. 431) as to control, respectively, remote-controlled switches Nos. 2, 3 and 4. In Fig. 513, the closing switches, A, of individual pilot switches Nos. 2

and 4 are placed in the set-up position. Then, by operating the closing switch of pilot switch No. 1 to the momentary position, remote-controlled switches Nos. 2 and 4 are simultaneously closed, and lamp-groups L and M are lighted thereby. The current-paths through the control wires and through the closing coils of the remote-controlled switches are, for this operation, indicated by the light arrows. The current-paths through the lamp-groups are indicated by the heavy arrows. The closing switches, A, may now be returned to the open position and the lighting effect will not be changed thereby.

How lamp-groups L and M may be simultaneously extinguished by pilot switch No. 1 will now be explained. Place the opening switches, B, of individual pilot switches Nos. 2 and 4 in the set-up position. Then

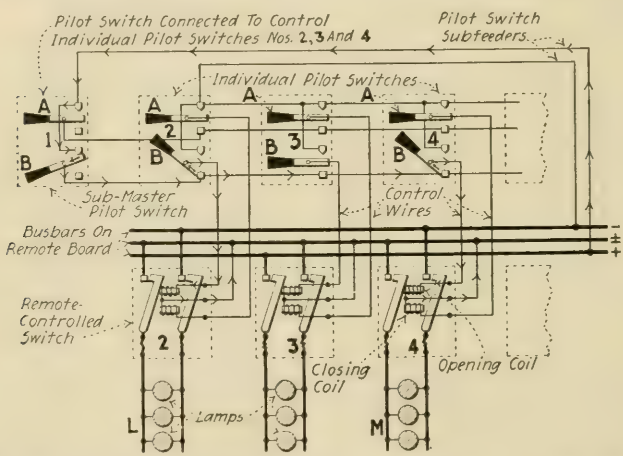


FIG. 514.—One pilot switch so connected as to control two or more other pilot switches. (The set-up and the indicated current-path is shown for extinguishing lamp-groups L and M.)

operate the closing handle, B, of switch No. 1 to the momentary position. Current will then flow through the control wires and through the opening coils of remote-controlled switches Nos. 2 and 4, as indicated by the arrows. When the current flows through the opening coils, the switches are (Sec. 323) opened, and the lamp-groups, L and M, are extinguished.

When a pilot switch is closed to the momentary position (A, switch No. 1, Fig. 513, and B, switch No. 1, Fig. 514), it is only necessary to hold it in this position for an instant. Then the hand should be removed from the handle, whereupon the switch will (Sec. 432) be returned to the open position. However, since the coils of the remote-controlled switches are (Sec. 323) designed for continuous duty, no harm other than a waste of energy will result if a pilot switch is held closed to the momentary position for an indefinite length of time.

435. A Circuit Diagram Which Illustrates The Major System is shown in Figs. 515, 516 and 516A. Theoretically, any number of individual pilot switches—and consequently the corresponding number of remote-controlled switches—may be controlled by one sub-master pilot switch. Also, theoretically, any number of submaster pilot switches may be

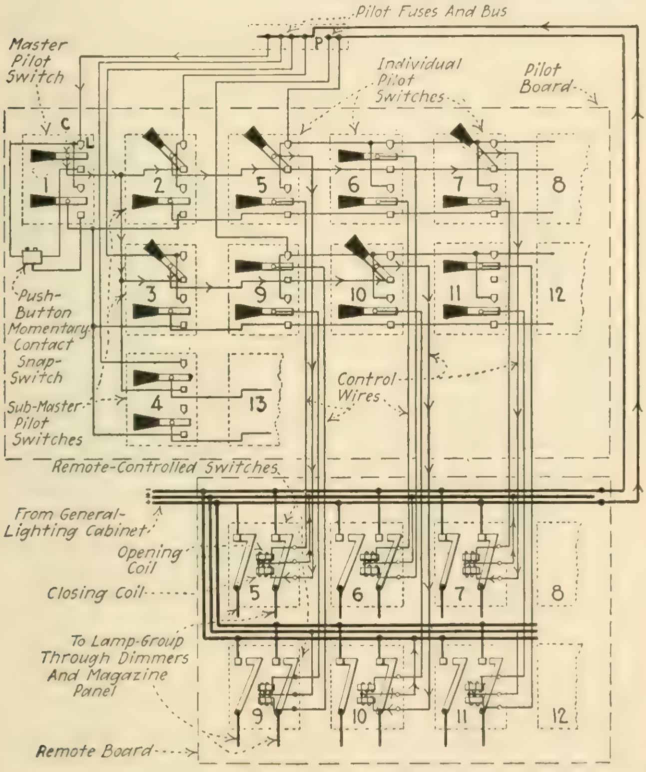


FIG. 515.—Simplified circuit diagram of the *Major* system of remote-controlled stage switchboard for an alternating-current system when not more than six individual pilot switches are controlled by one sub-master pilot switch, or for a direct-current system when not more than twelve individual pilot switches are controlled by one sub-master pilot switch.

controlled by one master pilot switch. However, practical considerations (Sec. 436) limit these numbers. The circuits shown in Figs. 515 and 516, and the control which is afforded thereby (see explanation below) typify the Major system.

Explanation.—The following explanation refers specifically to Fig. 515. The circuits are shown for one master pilot switch, No. 1, two sub-master pilot switches, Nos. 2 and 3, and six individual pilot switches. The six individual pilot switches, Nos. 5, 6, 7, 9, 10 and 11, control respectively the six remote-controlled switches, Nos. 5, 6, 7, 9, 10 and 11. The two sub-master pilot switches, Nos. 2 and 3, control, respectively the individual pilot switches Nos. 5, 6, 7, and 9, 10, 11. The master pilot switch, No. 1, controls the two sub-master pilot switches, Nos. 2 and 3. Each remote-controlled switch, Nos. 5 to 12, inclusive, controls (Sec. 431

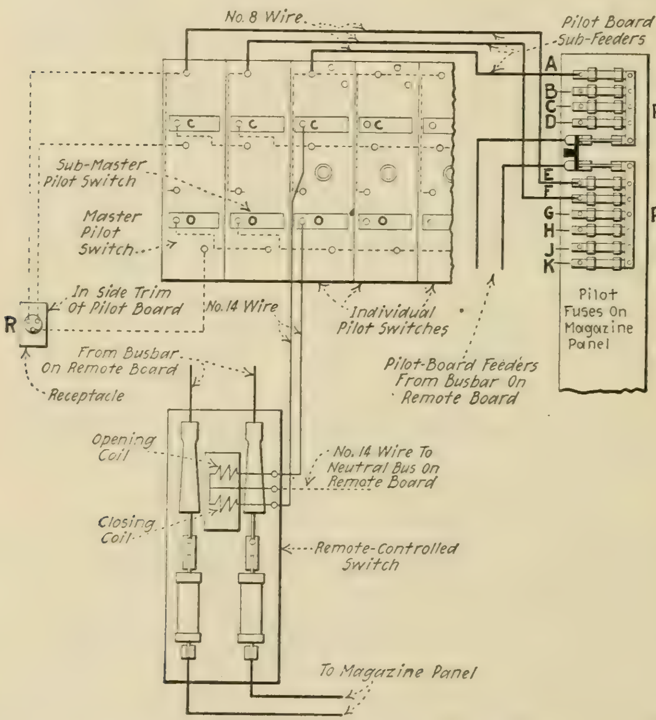


Fig. 516.—Connection diagram of control circuit used in the *Major* system for master, sub-master and individual pilot switches. (Not more than twelve individual pilot switches, when direct current; nor more than six individual pilot switches, when alternating current, to be controlled by one sub-master pilot switch.

and Fig. 509) one lamp-group. Thus, when a remote-controlled switch is opened or closed, that lamp group which is controlled by it is extinguished or lighted. The example which follows illustrates the simplicity of the operation of this pre-selective system.

EXAMPLE.—Assume that no stage lamps are lighted, that is, that the stage is "black out." Also assume that at a certain signal, the *white foots*, the *white border No.* 2 and the *red border No.* 1 must be lighted.

Note that each pilot switch is provided with a name plate, Fig. 510, which bears the name of the circuit that it controls. Further assume that the above-named lamp-groups are controlled respectively by the remote-controlled switches Nos. 5, 7 and 10, which are (see diagram, Fig. 515) in turn controlled, respectively, by individual pilot switches Nos. 5, 7 and 10. To set up the board for the desired change, the switchboard operator places the closing pilot switches (Sec. 433) Nos. 5, 7, 2, 10 and 3 in the set-up position. Then, when he receives the signal, he shifts the closing handle of the master pilot switch, No. 1, to the momen-

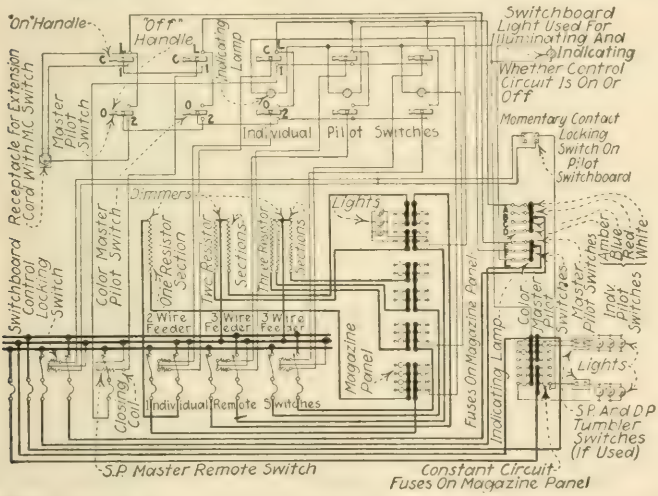


FIG. 516A.—Circuit diagram of a complete *Major* system of stage-switchboard control. (*Frank Adam Electric Co.*)

tary position (shown in dotted lines) and holds it there for a moment only. Whereupon, those lamp-groups which are controlled by remote-controlled switches Nos. 5, 7 and 10 are lighted simultaneously. The path, through the control circuits, of the current which operates remote-control switches 5, 7, and 10, as explained above, is indicated by the arrows.

After master pilot switch No. 1 has been closed for an instant to the momentary position the remote-controlled switches, Nos. 5, 7 and 10, are closed and locked closed (Sec. 323). They will not open until the opening coils are energized. Consequently, the closing-pilot switches, Nos. 2, 3, 5, 7 and 10 may now be returned to the open position and the lights which are controlled by them will not be extinguished. This enables the switchboard operator to pre-select and "set-up" in advance (Sec. 429) for the next lighting effect. Then when he receives the signal for this next

lighting effect, he can produce it instantly and simultaneously by the operation of the master-switch handles.

Assume that the next lighting effect requires the light from those lamp-groups which are controlled by remote-switches Nos. 5, 6 and 11. This is "set up" as follows: (1) *Return all of the opening pilot switches to the neutral position.* (2) *Place the closing pilot switches Nos.* 5, 6, 2, 11, *and* 3 *in the set-up position.* (3) *Place the opening pilot switches Nos.* 7, 2, 10 *and* 3 *in the set up position.* Now, when the signal is received for this second lighting effect, both the opening and closing switches of the master pilot switch, No. 1, are simultaneously operated to the momentary position and held there for an instant. This extinguishes Nos. 7 and 10, and lights Nos. 6 and 11, and permits No. 5 to remain lighted. The result is that the lighting effect of Nos. 5, 7, and 10, is instantly and simultaneously changed to that of Nos. 5, 6, and 11. The current path (arrows *not* shown) in the control circuit for this lighting change may be traced out by referring to Fig. 515.

It will be evident from the above that the lighting effect of any combination of any number of lamp-groups may be simultaneously changed to any other desired combination of any number of lamp-groups. Furthermore, any lamp-group may, by operating its individual pilot switch, be lighted or extinguished at any time without interferring with any other lamp-group.

436. A Single-pole Sub-master Remote-controlled Switch Is Provided On The Major Remote Board (Fig. 517) for each sub-master pilot switch when: (1) *One sub-master pilot switch controls more than six individual pilot switches for an alternating-current system.* (2) *One sub-master pilot switch controls more than twelve individual pilot switches for a direct-current system.* The connections are so arranged that the control which is provided is exactly the same as that explained under Sec. 435 in connection with Fig. 515. The reason for using these single-pole remote-controlled switches is, as explained below, to prevent the possibility of having to break an excessively heavy current with the master or sub-master pilot switches.

Explanation.—Assume that more than six, say seven, individual pilot switches are controlled by one sub-master pilot switch. Assume, also that the system is to be used on alternating-current and that the general scheme of connections is as shown in Fig. 515. Then, if it is desired to simultaneously light all of the lamps controlled by these seven individual pilot switches, each individual closing-pilot switch would be placed in the set-up position. The lamps would then be lighted by operating the sub-master closing-pilot switch to the momentary position. The alternating current which is required to close one Major remote-

controlled switch is (Sec. 323) about 7.7 amp. Then, the sub-master pilot switch would, when operated to the momentary position under the conditions outlined above, carry about $7 \times 7.7 = 53.9$ *amp.* Furthermore if all the lamps which are controlled by *two* sub-master switches were to be simultaneously lighted by means of the master pilot switch, the current which would pass through the master pilot switch would be: $2 \times 53.9 = 107.8$ amp. Such a heavy control current would, in addition to injurying the master or the sub-master pilot switches, require larger pilot fuses (Sec. 450) and, consequently, larger wires in the pilot-board feeder circuits.

To eliminate the objections which are outlined above, a single-pole remote-controlled switch (No. 2, Fig. 517) is connected into the circuit

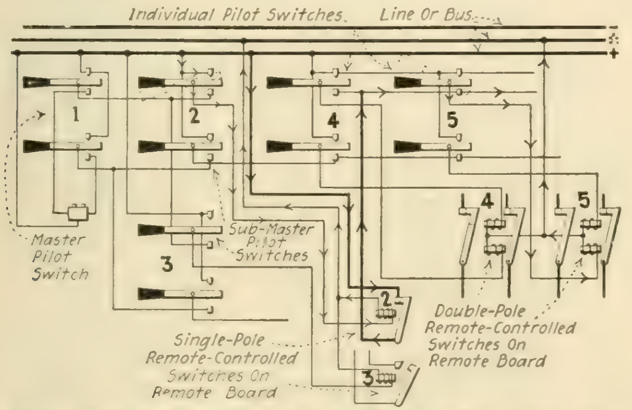


FIG. 517.—Simplified circuit diagram of the *Major* system of remote-controlled stage switchboard for an alternating-current system when more than six individual pilot switches are controlled by one sub-master switch, or for a direct-current system when more than twelve individual pilot switches are controlled by one sub-master pilot switch.

as indicated. As shown in Fig. 518, instead of connecting terminal *C* of the sub-master pilot switch to terminal 1 of the individual pilot switches, as in Fig. 516, it—terminal *C*— is connected to one side of the closing coil of the single-pole sub-master remote-controlled switch (No. 2, Fig. 517, and *A*, Fig. 518). The other side of the closing coil of switch No. 2, Fig. 517 and *A*, Fig. 518, is connected to the grounded side of the line. Switch *A*, Fig. 518, has no opening coil. It is opened by gravity and a spring (Sec. 323) when the control circuit through the closing coil is broken. One of the load-circuit wires, (*W*, Fig. 518, Sec. 316) of switch *A* is connected to the line or bus at *G*, and the other side, *V*, is connected to terminals 1—set-up terminals—of the individual closing pilot switches (switches 3, 4 and etc.) that are controlled by the sub-master pilot switch, No. 2, which controls *A*. Thus, when *A* (Fig. 518) is closed, current flows, as indicated by the arrows, (Fig. 517 and 518) to the set-up termi-

nals—terminals 1—of the individual pilot switches. Therefore, when the individual closing pilot switches are placed in the set-up position, current will flow through the closing coils of the corresponding remote-controlled switches. Consequently, instead of the circuit which carries this heavy current being broken by the master or sub-master pilot switches, it is made and broken by the single-pole remote-controlled switch.

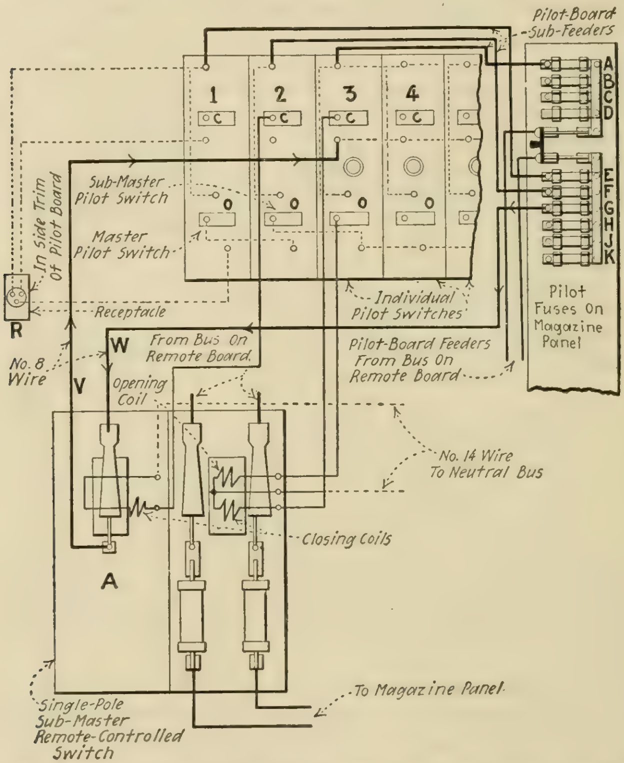


Fig. 518.—Diagram of control circuit of the *Major* system for master, sub-master and individual pilot switches. (More than twelve individual pilot switches, when direct current; or more than six individual pilot switches, when alternating current, to be controlled by one sub-master pilot switch. *Frank Adam Electric Co.*)

Since the current (Sec. 323) required to open the remote-controlled magazine switches is small—about 2.1 amp., alternating-current—a remote-controlled sub-master switch is not usually required in the opening circuit.

437. The Switches On A Major Pilot Board May Be Classified as: (1) *The stage pilot switches;* which control the stage

lights. (2) *The house pilot switches;* which control the house lights. (3) *The constant-circuit snap switches;* which control the work lights. Each classification is briefly described in the following sections (see also the specification, Sec. 452, Clauses, 27 and 28).

438. The Stage Pilot Switches Are Usually So Connected that: (1) *Each stage magazine circuit is provided with one individual pilot switch.* (2) *Each lamp-color is provided with one sub-master pilot switch.* (3) *One master switch controls all stage lights.* Thus, a sub-master pilot switch is, in effect, a color-main switch (Sec. 416). And the master pilot switch for the stage lights is, in effect, the stage-main switch (Sec. 416) (see Sec. 452, Clause 26).

Note.—The House Pilot Switches Are, In General, So Connected that the same arrangement of master, sub-master and individual pilot switches is provided with respect to the house as that which is explained above for the stage. However, where the number of lamp-groups for the house lights does not exceed 10 or 12, the sub-master pilot switches for house lights is sometimes omitted. In such cases, only a master pilot switch is provided for the house lights. It is so wired (Fig. 538) that it will control all of the house lights (see Sec. 452, Clause 27).

439. The Constant-circuit Snap Switches (Fig. 519) are usually single-pole, double-pole or three-way switches of the

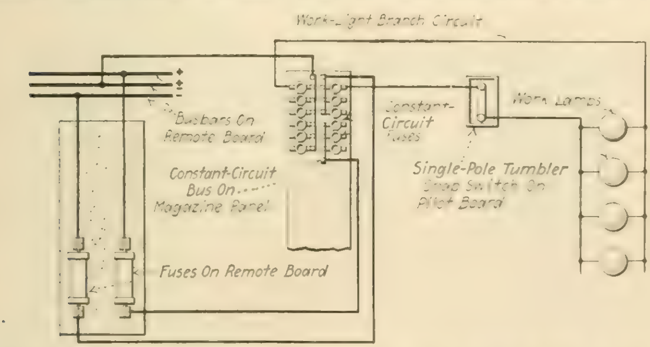


Fig. 519.—Circuit diagrams of the constant-circuit work lights as used in the *Major* system.

tumbler type. They are used to control the work lights (Sec. 415). The reason these circuits are called constant circuits is because the work-light branch circuits (Fig. 519) are con-

stantly connected to the bus-bars on the remote board; that is, they are not controlled by a remote-controlled switch as are the magazine circuits which feed the stage and house lights (see Sec. 452, Clause 28).

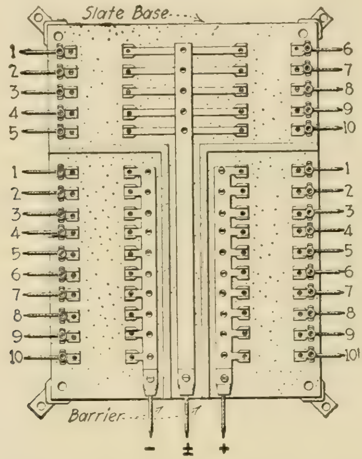


Fig. 520.—Three-wire-to-three-wire polarity type distribution panel.

440. A Polarity-type Distribution Panel (Fig. 520) is one wherein all of the branch-circuit connections of the same polarity are located adjacent to each other. Thus, in the

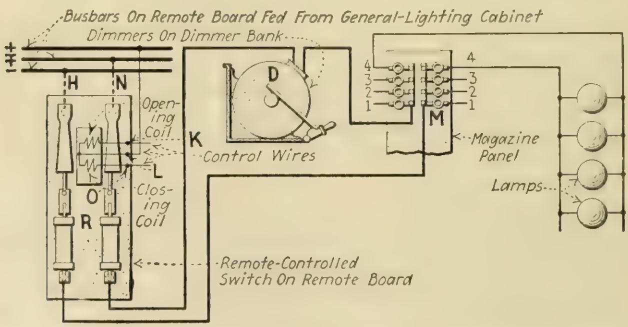


Fig. 521.—Showing method of connecting a section of the magazine panel (*Major* system) to the source of energy. Two-wire circuit to magazine panel.

three-wire polarity-type panel (Fig. 520), wires 1, 1, 1, form one three-wire branch; wires 2, 2, 2, form another three-wire branch, and so on (see also Fig. 535). In the two-wire

polarity-type distribution panel (*M*, Fig. 521), wires 1, 1, form one two-wire branch; wires 2, 2, form another two-wire branch, and so on. A polarity-type distribution panel does not usually require as much space as a panel (Fig. 547) of the ordinary type. This is because the clearance which is required between bare metal parts of the same polarity is not as great as that which is required between parts of opposite polarity (see Sec. 166). *The magazine panels* (*M*, Figs. 521 and 522) *as used in the Major system are of the polarity type.*

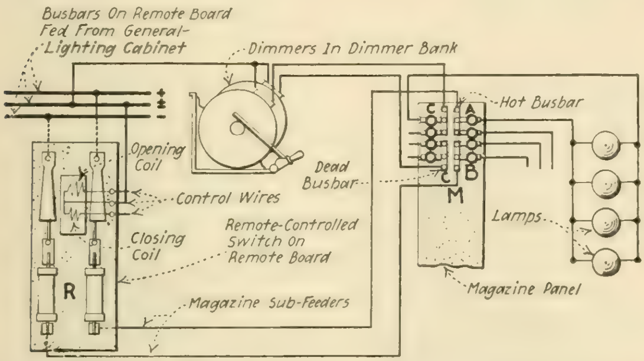


FIG. 522.—Showing the method as used in the *Major* system of connecting a two-pole remote-controlled switch as a three-pole switch. Three-wire circuit to magazine panel.

441. The Two Methods Of Connecting The Magazine Circuits To The Source Of Energy As Employed In The Major System are illustrated in Figs. 521 and 522. In Fig. 521, a two-pole remote-controlled switch, *R*, is connected, one pole to the neutral bus and one pole to one outside bus. The pole, *H*, which is connected to the outside or "hot" bus of the three-wire grounded-neutral system connects to one bus of the magazine panel, *M*. The neutral side, *N*, connects through the dimmer, *D*, to the other bus of the magazine panel, *M*. When the current required by the lamps which are connected to one magazine panel is large, the connections are made as shown in Fig. 522. The two-pole, remote-controlled switch (*R*, Fig. 522) is then wired as a "three-pole" switch. The hot busbar on the magazine panel, *M*, is divided into two sections *A* and *B*. One section is connected, through one

pole of R, to one outside wire, and the other section is connected, through the other pole of R to the other outside wire. The lamp load which is to be controlled by R is divided into two parts which are as nearly equal as is practicable. One part is connected to A. The other part is connected to B. Then the two neutral busbars, C, are connected through the dimmers to the neutral bus on the remote board (see also Sec. 446 concerning dimmer connections).

442. The Major Pilot Board Is Fed From The Busbars On The Remote Board (B, Fig. 523) by the pilot-board feeders, F, through the magazine-panel pilot-board busbar, P. At

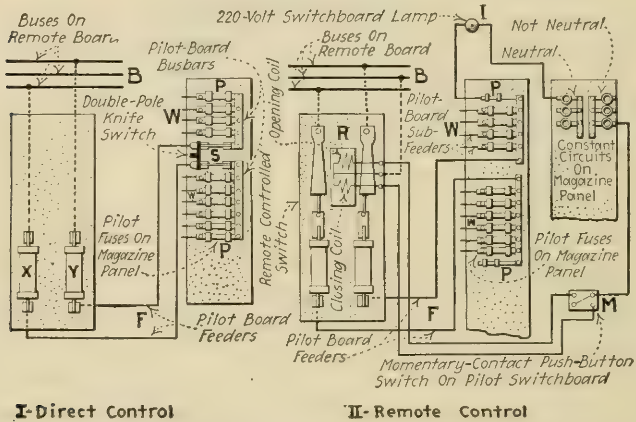


FIG. 523.—Circuit diagram showing how the pilot board is fed in the *Major* system.

P, the circuit is divided into the fused pilot-board sub-feeders, W, which feed directly to the various pilot switches. (See Figs. 516 and 518.)

NOTE.—THE MAJOR REMOTE CONTROL SYSTEM MAY BE "LOCKED" by either one of two arrangements: (1) *By opening the double-pole knife switch*, S, Fig. 523-*I*. (2) *By pressing the button of momentary contact switch* M which opens the remote-controlled switch, R, Fig. 523-*II*. That is, such house or stage lamps as are desired may be lighted as explained in Sec. 435. Then, by opening S or R (Fig. 523) no current can flow through the opening or closing coils of the remote-controlled magazine switches. Consequently, none of the stage or house lamps can then be lighted or extinguished. Thus, by providing a lock on S or M, the stage and house lamps may be "locked" when either lighted or extinguished. Opening S or R also cuts the pilot board dead so that changes

or repairs may be made with safety. Opening S or R does not in any way affect the constant circuits (Sec. 439). By connecting lamp I (Fig. 523-II) as shown, it will be lighted when switch R is closed, and extinguished when R is open. Thus, it indicates whether the pilot board is "dead" or "alive." It is usually mounted (I, Fig. 537) in the top trim of the pilot board.

443. The Indicating Lamps On A Major Individual Pilot Switch are connected as illustrated in Fig. 524. When connected as shown, the indicating lamp of each individual pilot switch will be lighted when the lamps which are controlled by that individual pilot switch are lighted; and it will be extinguished when the lamps which are controlled by that individual pilot switch are extinguished. Thus, the switchboard operator may, by a glance at the pilot board, know just which stage and house lamps are lighted and which are not lighted. The indicating lamp will, when connected as shown, burn at full brilliancy, even though the lamps are dimmed by the dimmers. The positions of the dimmer handles, or a pointer which may be provided on the dimmer, indicate the brilliancy of the lamps which the dimmer controls. The master and sub-master pilot switches are not provided with indicating lamps.

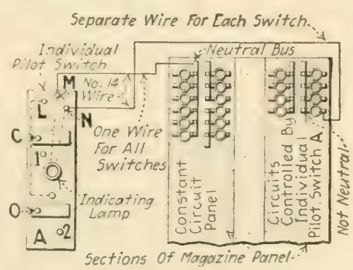


FIG. 524.—Circuit diagram showing how the indicating lamp of a *Major* individual pilot switch is connected.

444. In The Major System All Of The Stage And House Lights May Be Controlled By A Momentary-contact Switch which is really an auxiliary master switch (Fig. 525). This momentary-contact switch may be stationary and mounted at any desired location in the theatre. Also, it may be portable (Fig. 507) so that control of the stage and house lights may be had from the most advantageous location (see explanation below).

EXPLANATION.—For the example which was explained under Sec. 435, in connection with Fig. 515, the set-up was made and the lamps were lighted by closing the closing-switch of the master pilot switch, No. 1,

to the momentary position. This permitted the current to flow from L to C (Switch No. 1, Fig. 515). By operating a two-circuit momentary-contact switch which is connected to the master pilot switch, as shown in Fig. 525, the closing-switch of the master-pilot switch (Fig. 525) being previously placed in the set-up position, the same result may be obtained. That is, by closing the momentary contact switch, as shown at M, current will flow from L to C as indicated by the arrows. Thus, the lights may be lighted or extinguished by the momentary-contact switch of Fig. 525, just as they were lighted or extinguished by the master pilot switch of Fig. 515.

The *Frank Adam Electric Co.* regularly equips all Major boards with a three-point receptacle (R, Figs. 516, 518 and Sec. 452, Clause 26) which is located (Fig. 507) in the side trim of the pilot board. About 50 ft. of No. 14, three-conductor stage cable (W, Fig. 525, and Fig. 507)

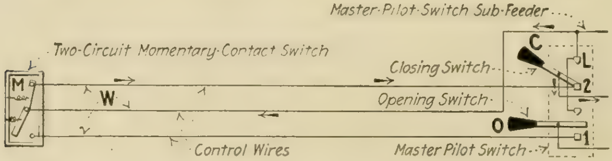


FIG. 525.—Showing the method, which is used in the *Major* system, of controlling the house and stage lamps by a momentary-contact push-button switch. (*Frank Adam Electric Co.*)

is also furnished. A two-circuit momentary-contact switch is connected to one end of this cable, and a three-point plug is connected to the other end. By inserting the plug into the receptacle (Fig. 507), the stage and house lamps may be controlled from almost any location on the stage by the momentary contact switch, as explained above. In some scenes it is difficult for the switchboard operator to get the signal for a lighting change from his usual position at the stage switchboard. In such cases, he may place the proper switches in the set-up position, plug in the cable, and take the momentary-contact switch in his hand and go to a place where he can readily receive the signal. Or, if desirable, the momentary-contact switch may be temporarily mounted in the scenery, so that it can be operated by the actor in full view of the audience. Then, the switchboard operator merely places, in advance, the proper switches in the set-up position and the actor controls the lights.

445. Theatre Dimmers Are Used To Dim The House And Stage Lights. A dimmer is merely a rheostat—a resistor of variable resistance (Fig. 526)—which is connected into the magazine sub-feeder that feeds the lamp-group to be dimmed. The dimmers are mounted in a group, called the *dimmer bank,* above the stage switchboard (Figs. 502 and 527), or in rear of

or on top of the pilot board (Sec. 431 and Fig. 507). Each dimmer unit is provided with an individual handle. Shafts

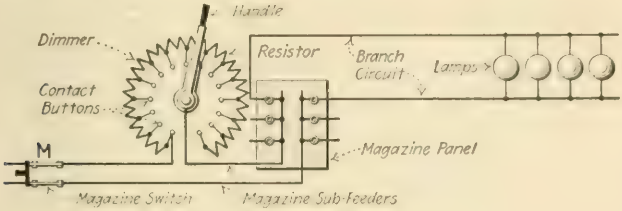


Fig. 526.—Simple dimmer circuit.

which are equipped with master and grand-master handles (Figs. 507 and 527) for interlocking several dimmer units for

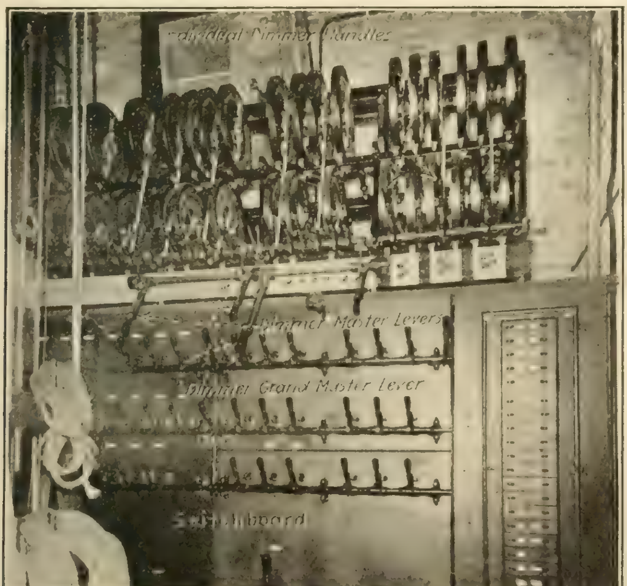


Fig. 527.—Dimmer bank mounted above a dead-front, manually-operated, interlocking stage switchboard. (*Mutual Electric & Machine Co.*)

simultaneous operation are also provided. Various methods of dimmer connections are discussed in the following sections.

446. The Dimmers Must Be So Wired That They Are Dead when the switch which controls the circuit of which the dimmer

forms a part is open. (Code Rule 38*c*, 2.) Compliance with this rule requires that the magazine switch (*M*, Fig. 526) be a double-pole switch. Or if the dimmer is connected into the grounded-neutral of a three-wire system, it may be connected as shown in Fig. 522. Although, when the switch, *R*, Fig. 522, is open the dimmer is not disconnected from the line, it is, since it is in the grounded side of the circuit, considered to be dead.

447. The Maximum Wattage Rating Of A Single Dimmer Plate is about 3,000 watts. When the magazine circuits which are connected to one magazine-panel section have a connected load greater than 3,000 watts, two or more dimmer plates are mounted as one unit. Then this unit is controlled by one individual handle. The method of connecting two or more dimmer plates to dim a single lamp-group is discussed in the following section.

448. The Correct Method Of Connecting A Multi-plate Dimmer Unit is shown in Fig. 528-*I*. The magazine panel

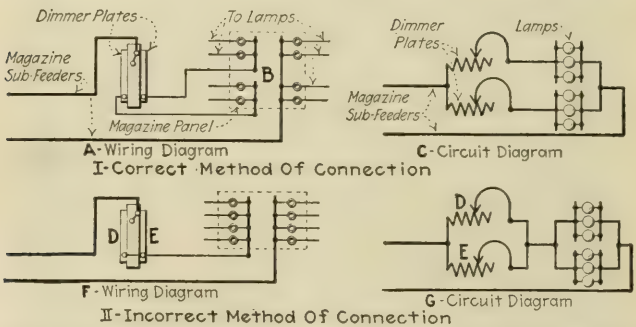


Fig. 528.—Showing correct and incorrect method of connecting multi-pole dimmer units.

bus-bar, *B*, should be divided into as many sections as there are dimmer plates in the dimmer unit for that lamp-group. Then one dimmer plate should be connected to each bus-bar section, as indicated in Fig. 528. The load on the branch circuits which are connected to any one dimmer plate should be made as nearly equal to the wattage rating of that dimmer plate as is practical.

Note.—An Incorrect Method Of Dimmer Connections is shown in Fig. 528-*II*. When connected as shown, the dimmers will work as long

as each dimmer plate operates satisfactorily. However, if trouble develops on one dimmer plate and puts it out of service, the entire load will then be carried by the remaining serviceable plates of that unit. Such a load shift may cause the entire unit to burn out before the trouble can be remedied.

449. The General Rule To Be Followed In Fusing Stage-switchboard Circuits is to place a fuse of the proper rating (Sec. 170) at every point where a change is made in the wire size. Compliance with this rule will, in general, require fuses in the stage-main, house-main, color-main, and magazine circuits; also in each branch circuit at the magazine panel. Since each the stage-main, house-main, color-main and magazine circuits are usually provided with switches, the fuses and switches should, when practical, be so arranged that the fuses in any circuit will be dead when the switch which controls that circuit is open. The above applies, in general, to all types of stage switchboards. See Figs. 492, 493, 495, 496, 497, 499, 500, 502, 503, 504, 506, 508, 516, 518, 519, 522, 523, and 524. Some of the special fusing which is generally followed in the Major system is discussed in the following sections.

450. The Method Of Fusing Which Is Employed In The Major System is discussed below. In addition to complying with the general fuse requirements which are mentioned in Sec. 449, the Major system contains certain features which provide a protection against complete failure due to fuse blowing. These features are described in the following notes. In the major system, the pilot-board fuses seldom if ever blow because the circuits which they protect are not normally subject to troubles or to derangement.

Note.—The Method Of Fusing And Feeding The Major Pilot Board is shown in Figs. 515, 516, and 523-*I*. The pilot-board bus on the magazine panel is divided into two sections (*P* and *P*, Fig. 523). Each horizontal row of individual pilot switches as Nos. 5, 6, 7, and 9, 10, 11, Fig. 515, is fed (Fig. 516) through a separate fused conductor (*A*, *B*, and *C*, Fig. 516), from the upper section of the bus, *P*. Each section of *P* is fed from the buses, *B*, Fig. 523-*I*, through the fuses, *X* and *Y*. Thus, if any or all of the fuses, *A*, *B* and *C*, Fig. 516, should blow, the pilot board may still be operated through the medium of the master and sub-master pilot switches. Also, if the fuse in *E* (Fig. 516) should blow, the pilot board is still operative through the sub-master or individual pilot

switches. If any or all of the fuses in *F*, *G*, or *H* (Fig. 516) should blow, the board may be operated through the master and individual pilot switches. If all of the fuses on the lower section should blow (those in *E*, *F*, *G*, and *H*), the board may be operated by the individual pilot switches. If either of the main fuses (*X* or *Y*, Fig. 523) blow, the pilot board may be operated through the individual pilot switches or through the master and sub-master pilot switches.

451. A Method Which Is Sometimes Employed In Wiring The Footlights is illustrated in Fig. 529. As shown, alternate lamps in the footlight trough are connected to the same magazine sub-feeders, and every fourth lamp is connected to the same branch circuit. Thus if one of the fuses, *F*, in the magazine sub-feeder, blows, one half of the lamps will be

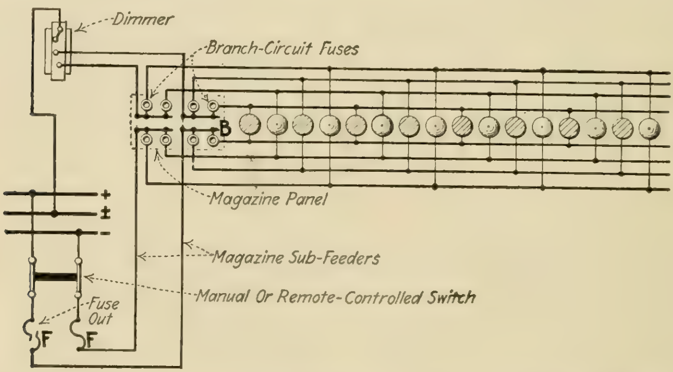


Fig. 529.—Showing method of connecting footlights to alternate circuits. (This shows the wiring for the lamps of only one color. Similar circuits are used for each of the three colors.)

extinguished, but the illumination therefrom will be evenly emitted throughout the entire length of the trough. Also, if one of the branch-circuit fuses, *B*, should blow one fourth of the lamps will be extinguished, but the illumination from the remainder of the lamps will be evenly distributed. This method of wiring the more important stage circuits will sometimes prevent having to stop the show during a scene. This method may also be employed for *border and proscenium lights.*

452. The Specification For The Electric Wiring Of The Indiana Theatre, Terre Haute, Ind., is contained in the following pages. It may be considered as a typical specifica-

tion for the electric wiring of a modern theatre which is designed for both motion-picture and dramatic performances. *John Eberson*, Chicago, Ill., was the architect. The electrical specification was prepared with the cooperation of R. E. Major of the Major Equipment Co., of Chicago. The installation called for in this specification was made by *The Pierce Electric Co.*, Chicago, Ill. Only a few minor changes in arrangement have been made by the author.

INDEX TO SPECIFICATIONS FOR ELECTRIC WIRING

SPECIFICATIONS FOR ELECTRIC WIRING, INDIANA THEATRE, TERRE HAUTE, INDIANA

1. GENERAL: The foregoing pages of General Conditions shall apply to this branch of the work. (*These General Conditions are not printed in this book*, EDITOR.)

2. SCOPE OF THIS WORK: These specifications contemplate the furnishing of all materials and labor required for a complete and high grade installation of light and power wiring for this theatre building, including feeders, panel boards and switchboards, fuse blocks and fuses, conduits and wires for the distribution of the lighting and power outlets called for on plans (see pictures of plans, Figs. 530, 531, 532, 533 and 534) or mentioned in these specifications; also including all outlet boxes and outlet box covers, receptacles and plates, drop cords, lighting switches, motor switches, service switches, a Major Combination Pilot Board and Dimmer Bank, remote board, borders, foot lights, proscenium strips, exterior decorative illuminating wiring, picture machines, house telephones, conduits for public telephones, signal system, and all apparatus shown on plans and mentioned in these specifications to make this installation complete, from the service company's feeder to the most remote outlet, all ready for the attachment of fixtures and the lamping up of the house. All of the above to be to the entire satisfaction of the supervising architects and owner and all as described in these specifications.

This installation will not include the incandescent lighting fixtures; it will not include the furnishing of any motors shown on plans in connection with the ventilating and heating system or elevator service or vacuum cleaner. However, it shall include necessary labor and materials to connect the motors shown and described on plans and specifications in connection with the following branches of the work:

Motors for plumbing system.
Motors for heating and ventilating system.
Motors for organ.

It shall also include connecting up of moving picture machines, spot lights and other arcs which are to be furnished for picture booth by others.

3. MATERIAL AND WORKMANSHIP: All materials furnished, and methods of installation of same, shall be in full accord with the latest and best modern electrical and mechanical engineering practices. Although these specifications are intended as electrical specifications, contractor shall install all work in the best mechanical manner. All material and apparatus used in this building shall conform in all respects with the rules and requirements of the Electrical Inspection Department of the City of Terre Haute, Indiana, and the rules and regulations enforced in this city by the National Board of Fire Underwriters.

4. INSPECTION: Contractor shall apply for a permit from the Electrical Inspection Department of the City of Terre Haute, before

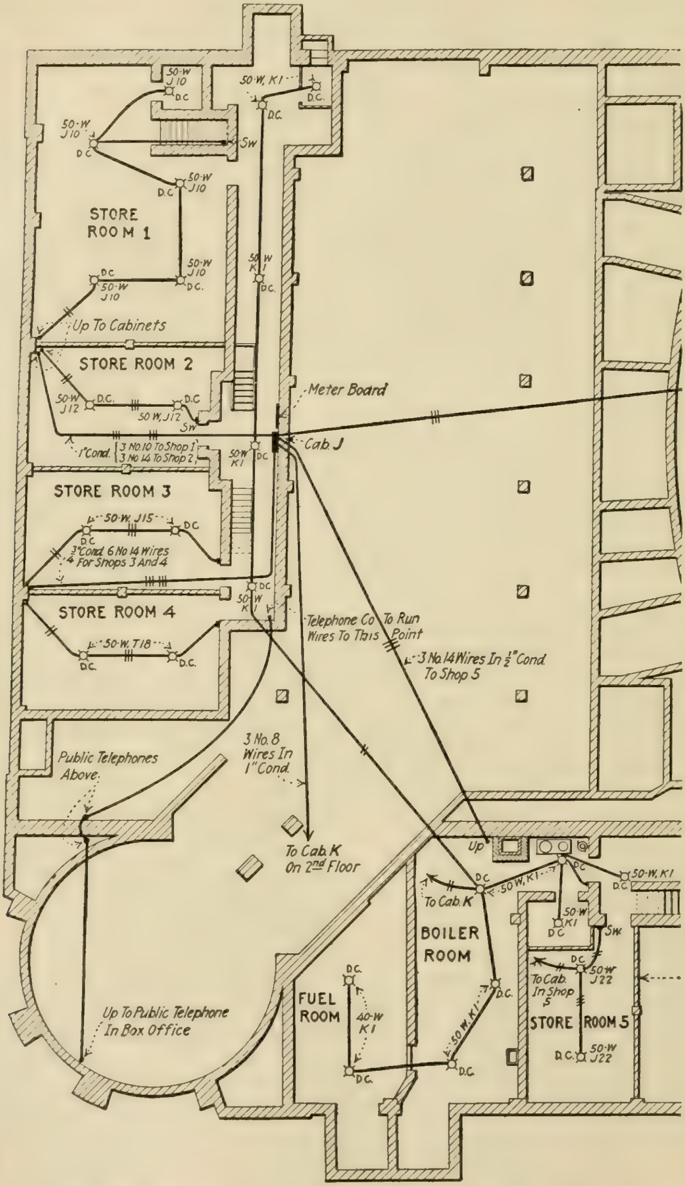


Fig. 530.—Basement plan of Indiana Theatre, Terre Haute, Ind., showing

electrical wiring. (*Pierce Electric Co.*) (See Fig. 532 for electrical symbols.)

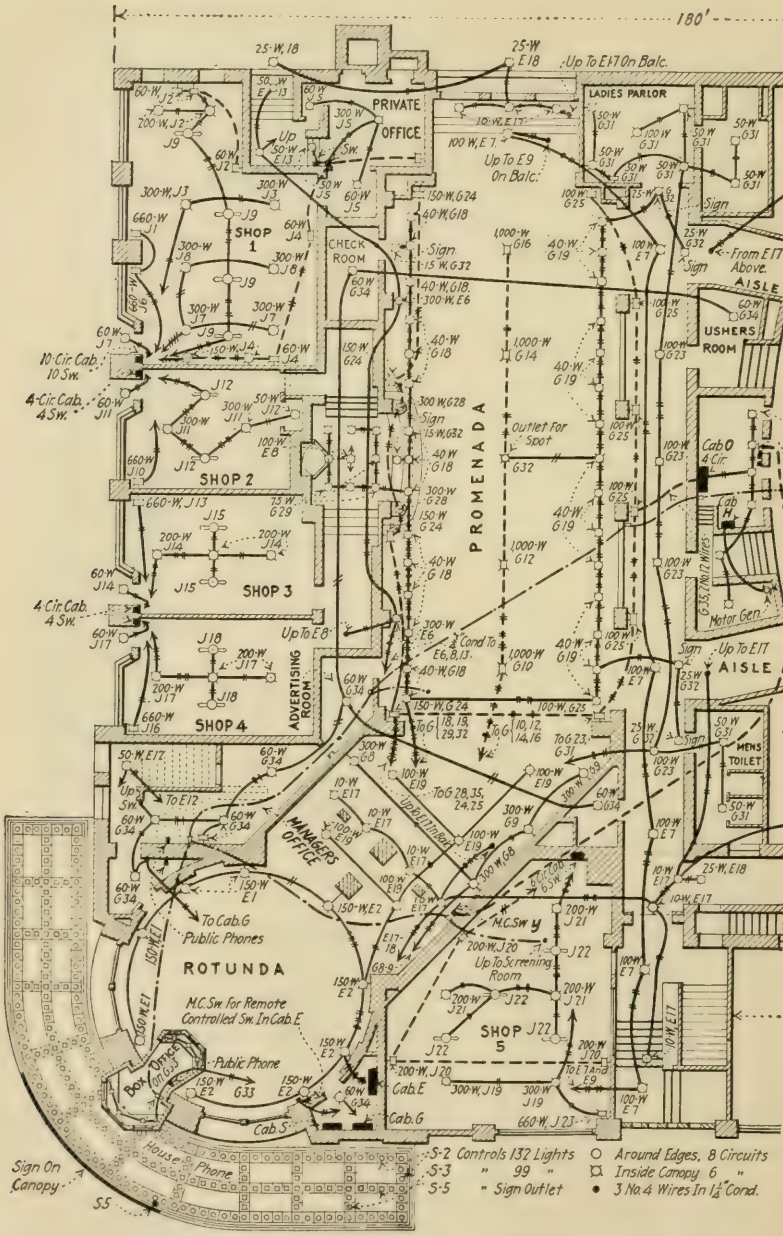
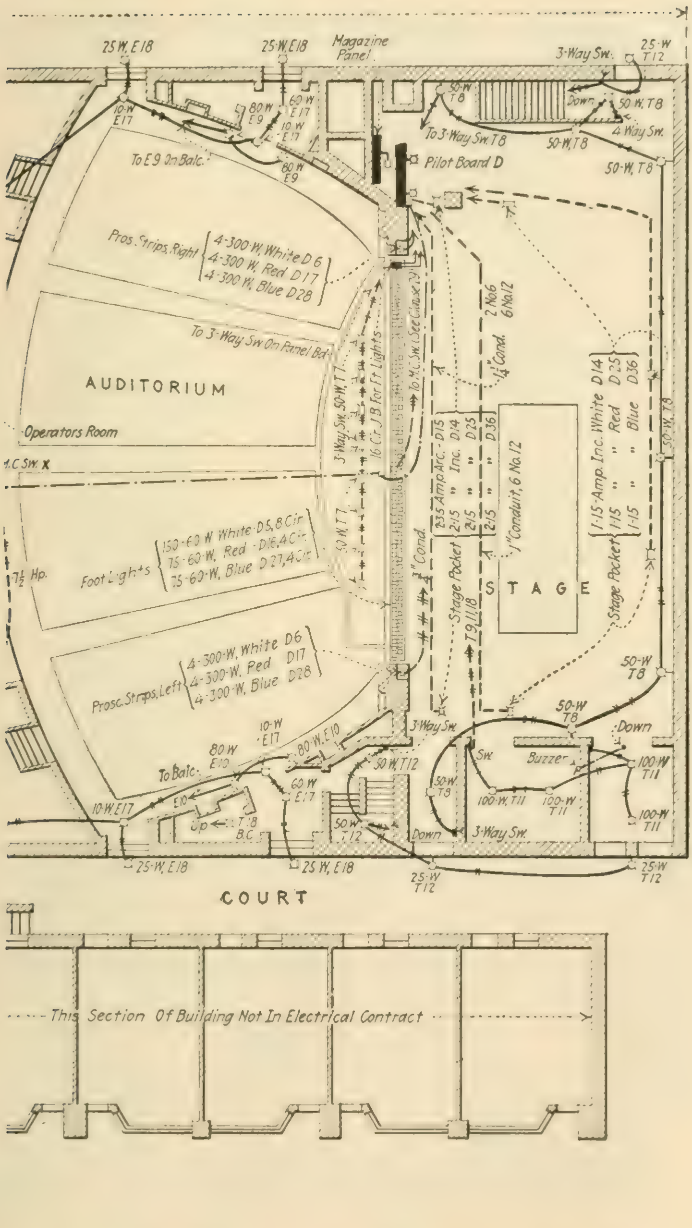


FIG. 531.—First floor plan of Indiana Theatre, Terre Haute, Ind., showing



electric wiring. (*Pierce Electric Co.*) (For electrical symbols see Fig. 532.)

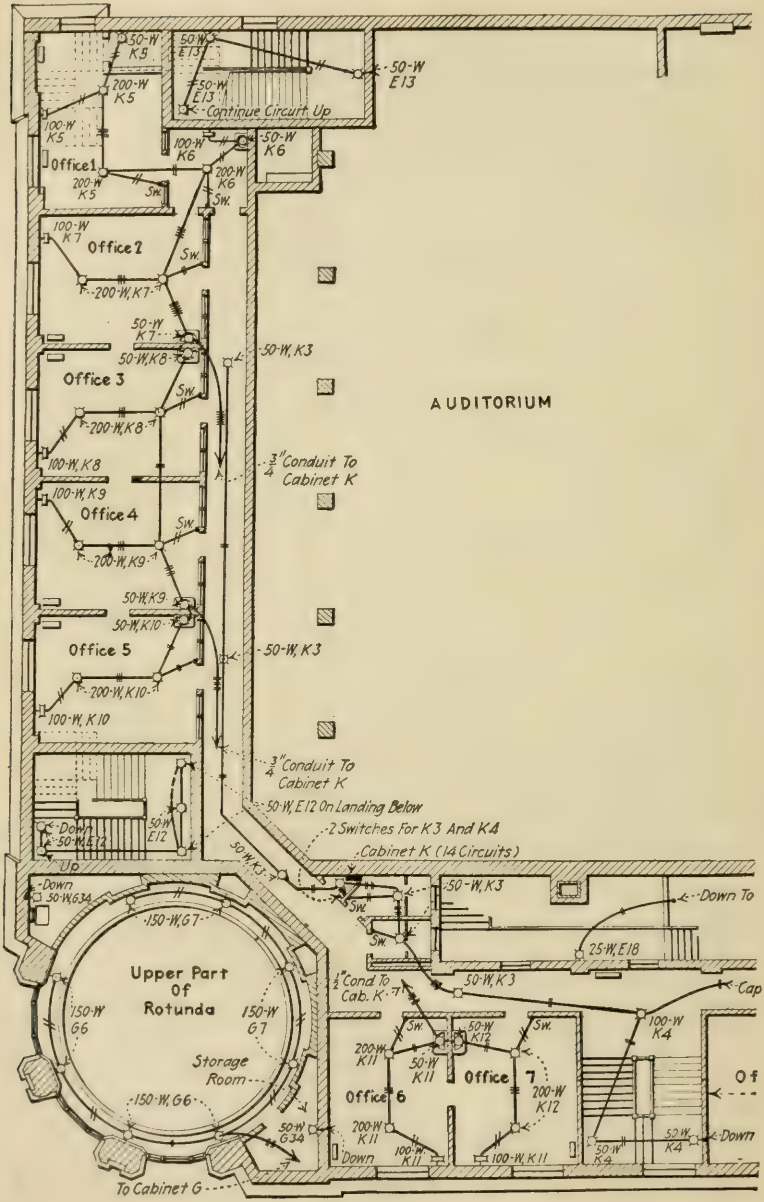
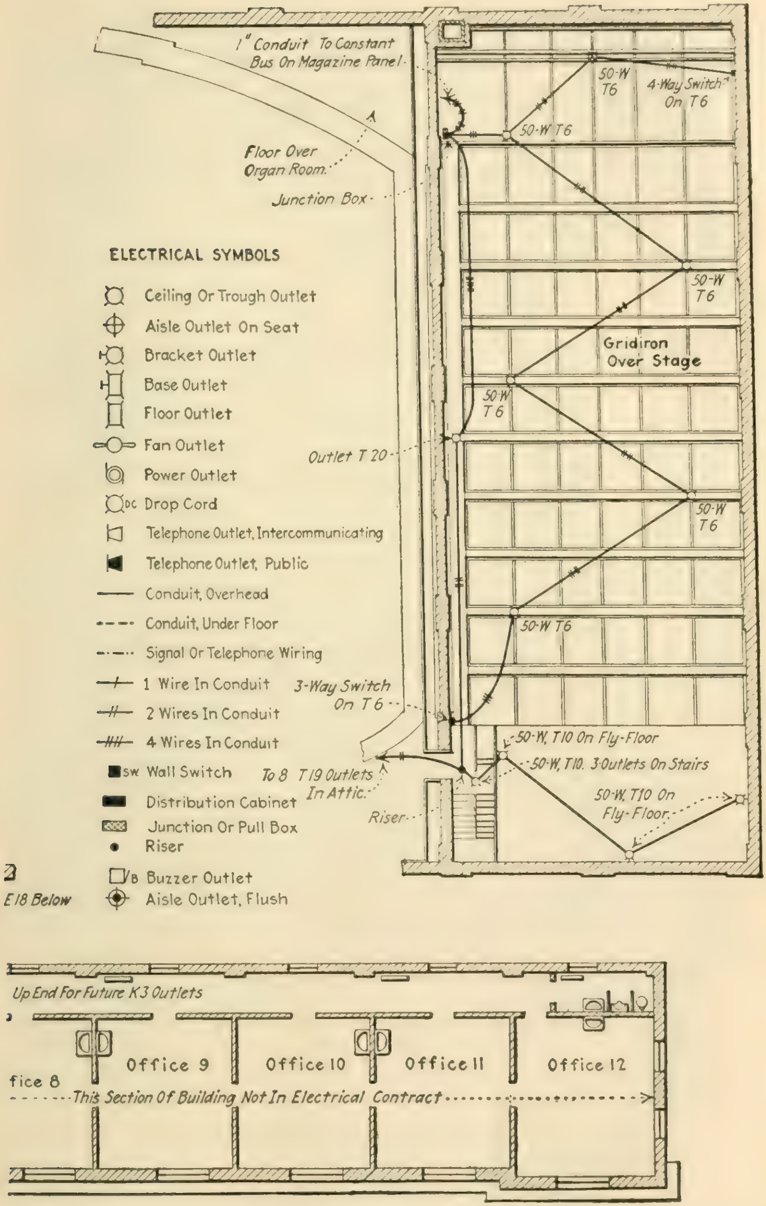


Fig. 532.—Second floor and gridiron plan of Indiana Theatre,



Terre Haute, Ind., showing electric wiring. (*Pierce Electric Co.*)

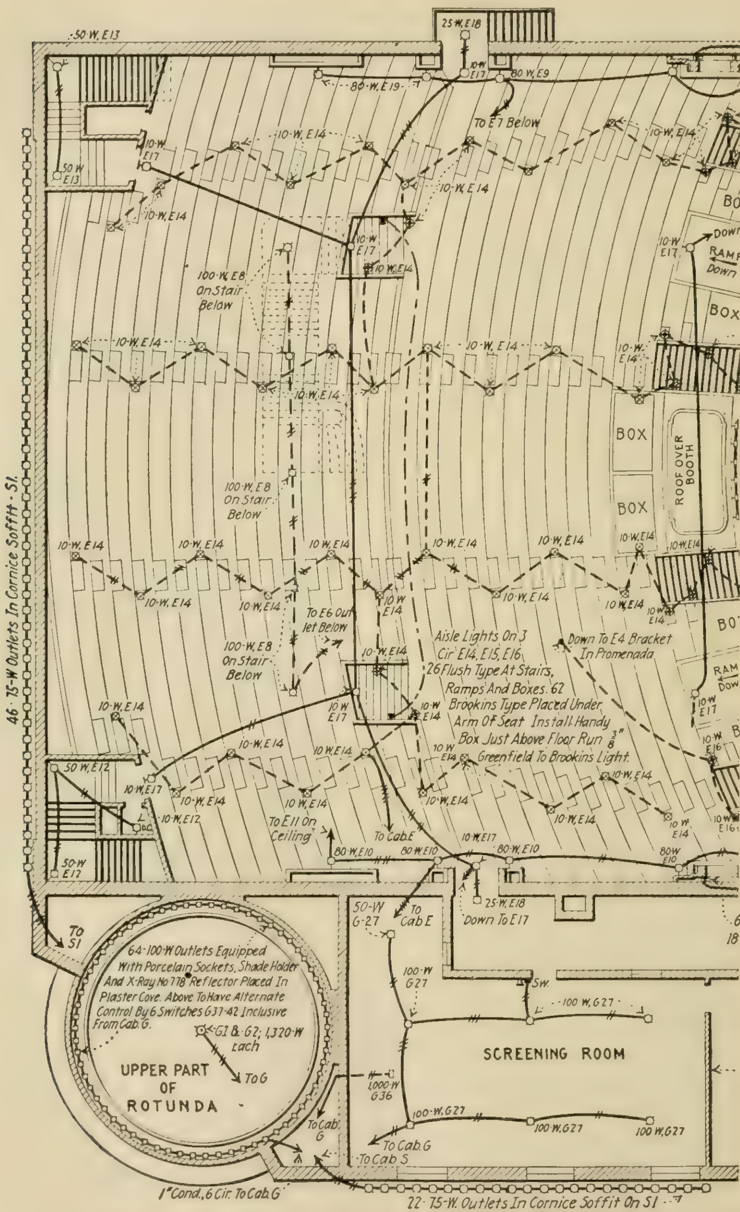
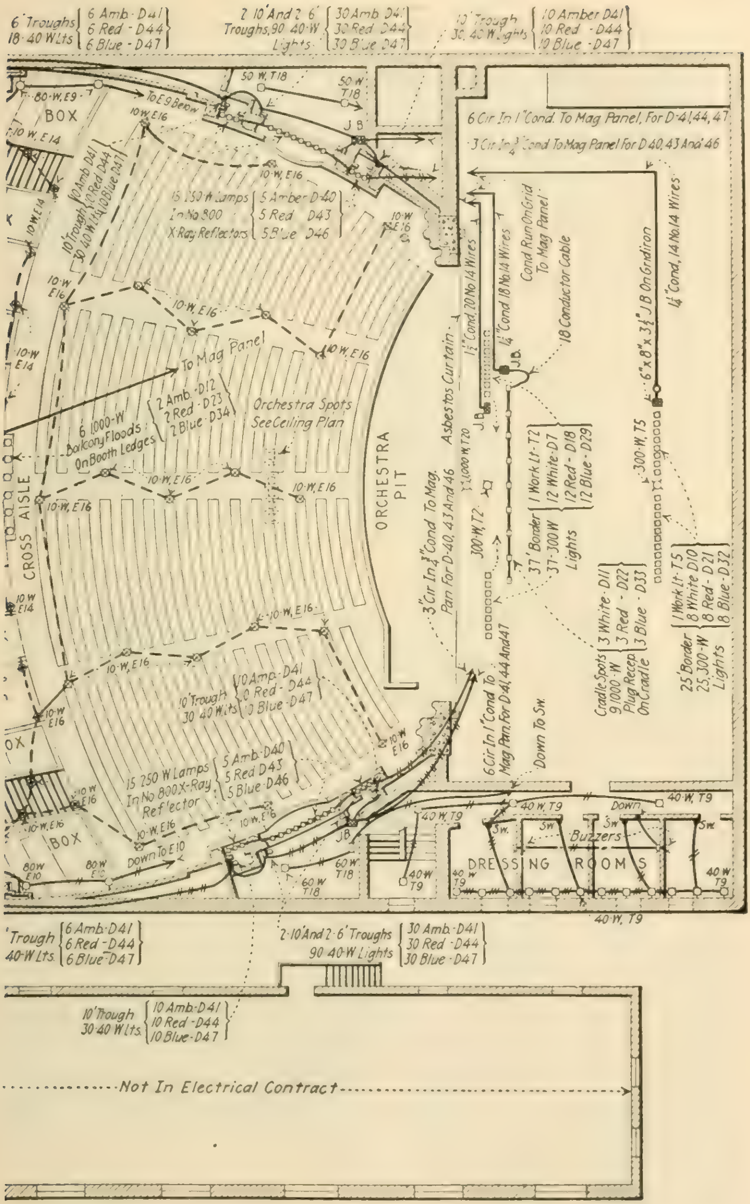


FIG. 533.—Theatre and third floor plan of Indiana Theatre, Terre Haute, Ind.,



showing electric wiring. (*Pierce Electric Co.*) (See Fig. 532 for electrical symbols.)

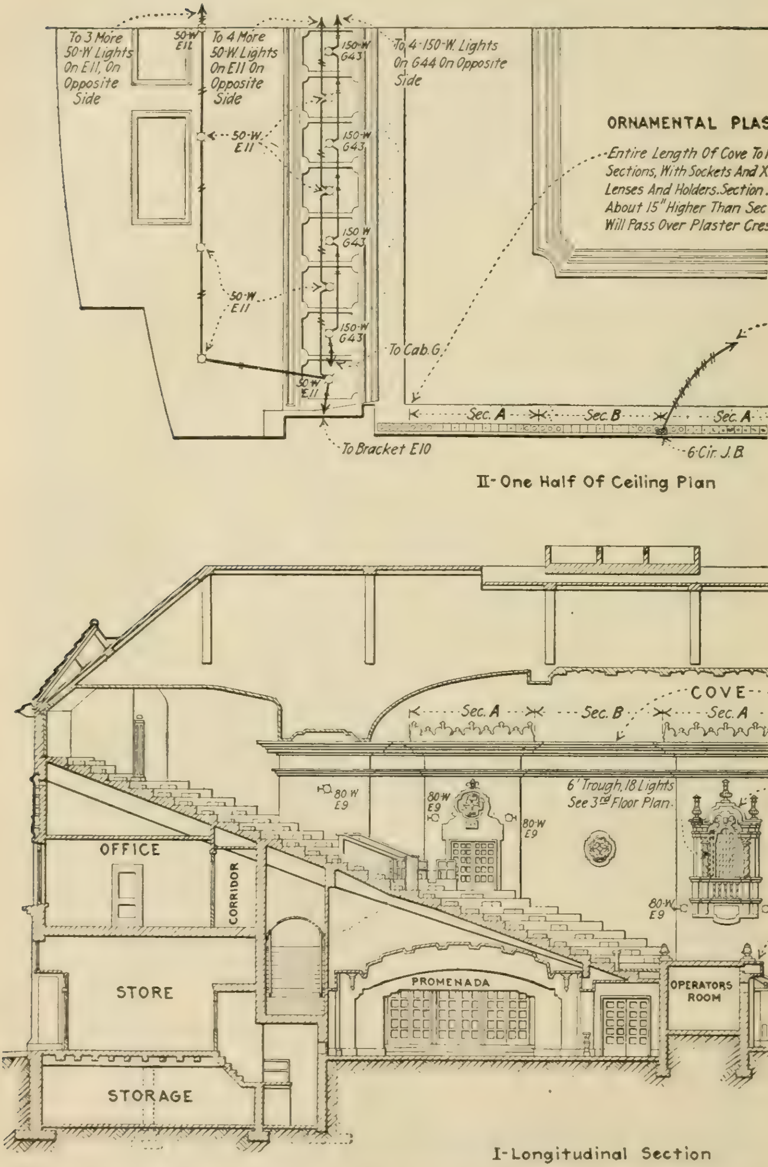
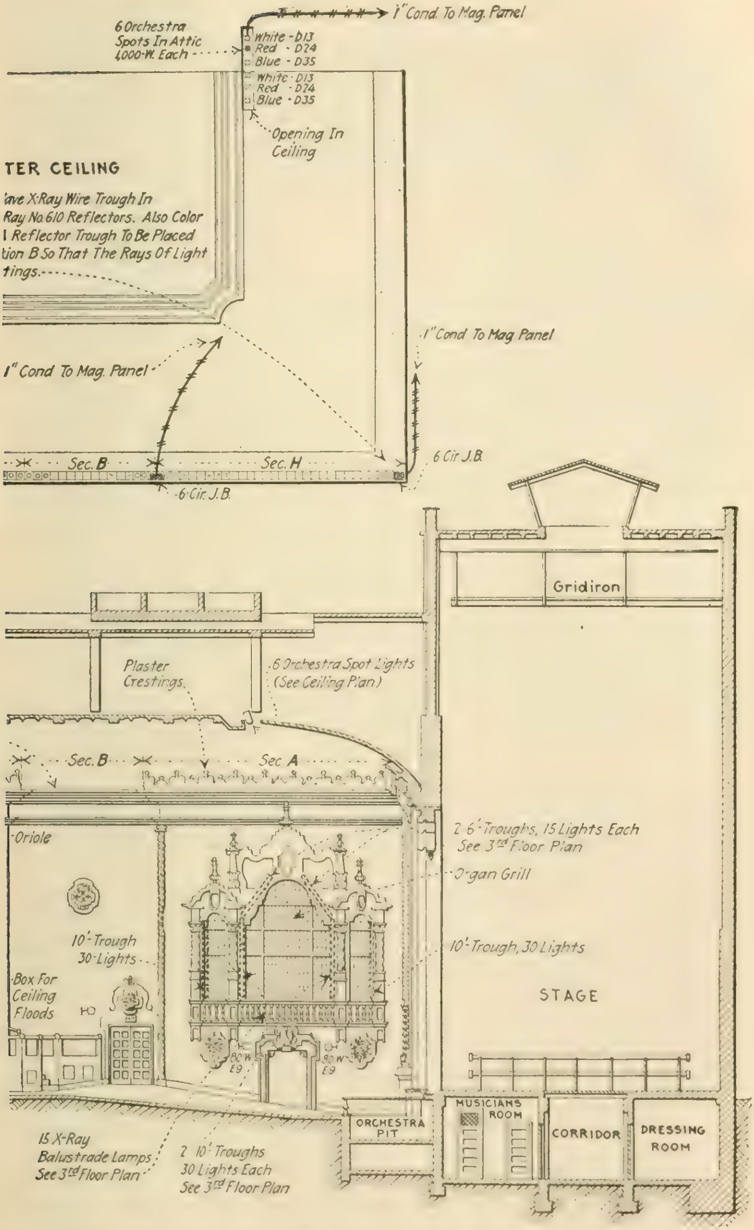


Fig. 534.—Longitudinal section of the Indiana Theatre, Terre Haute, Ind.,



showing electric wiring. (*Pierce Electric Co.*) (See Fig. 532 for electric symbols.)

starting his work, notify that department when the work is ready for inspection and pay the final inspection fee on all incandescent lights, arc receptacles, signs and motors in the building. The certificate of inspection shall not release the contractor from any defects in material, workmanship or design, should any develop within one year after final acceptance of the work herein specified. Contractor shall make all changes and repair any defects directed by the supervising architect, promptly, upon written notice, and without additional expense to the owner.

5. WORKING DRAWINGS: The contractor must furnish a set of prints showing location of all outlets and special apparatus as mentioned in the "Scope of the Work," Clause 2, together with all wiring and conduit system showing sizes of same, and shall also make a drawing of the service and stage switchboards and the cabinets and panels, furnishing blue prints to the architect and owners for their approval, before starting the work. The detail shop drawing for all switchboards and panel boards must be submitted for the architect's and owner's approval. This is important and will be insisted upon.

6. ELECTRICAL ENERGY SUPPLY: The system of electrical energy (current) supply for lighting system will be alternating current, 3-wire, 110–220-volt, single-phase. The system of energy supply for power service will be alternating current, 440-volt, 2-phase, 4-wire. All feeders and mains for light will be on a 3-wire system. Branch circuits in lighting system to various outlets to be run on 2-wire system.

7. METHOD OF WIRING: All wiring in this building for light, arcs, motors, telephone and signal systems shall be run in iron conduit. All conduits throughout the entire installation shall be run concealed, except the runs on the stage. The conduit will be run in floor construction, attic space, partitions, and when run on brick walls where plaster occurs, contractor will cut the necessary chases in the brick in order to have the conduit covered with plaster where the plaster is put directly on the brick. Conduit runs for outside lights such as fire escape lights, shall be run inside of the building and come through to the outside of the building only at the outlets. It is intended that the conduits in the entire installation shall form a complete raceway from the service board to each of the distributing centers and from the distributing centers to all the lighting and motor outlets. No wires are to be pulled into the conduits until the plastering has been done.

8. CONDUIT: Conduit will be loricated iron pipe. Conduit will be carefully reamed to remove all burrs, and ends of pipe must butt into couplings. All conduits shall be run in long runs and not more than four quarter bends shall be made in one run of conduit. The necessary pull boxes or condulets can be inserted as desired in long runs of conduit to facilitate the pulling of wires. In no case shall a pull box be installed in an inaccessible location. Conduits when entering outlet boxes or cabinets shall be firmly fastened to same by lock nuts and bushings. Conduits in the entire installation shall be firmly fastened to the structure of the building.

9. GROUNDING: The conduit shall be grounded in an approved manner in at least two places.

10. WIRE: Wire used in this installation shall consist of tinned copper of 98 per cent. conductivity, to have a rubber insulation around the conductor of a thickness as given in the latest requirements of the City Electrical Inspection Department. The insulation is to have a double braid covering, for all wires larger than No. 8. Wire of the following companies will be acceptable for use in this work: *G. E. Red Core, Simplex Wire & Cable Co., American Steel & Wire Co., Standard Underground Cable Co.*

11. SIZE OF WIRE: The size of wire for distributing circuits for all purposes and main feeders shall be not less than the size given in the rule book of the Electrical Inspection Department, based on the entire load being in operation at one time. After obtaining the total current that each feeder carries, contractor shall refer to the rule book and select the size of wire required and then install the feeder consisting of the necessary number of the above size cables to constitute the entire feeder. On distributing circuits, more than one circuit may be run in one run of conduit, as described by the code rules. On borders, proscenium strips, foot-lights, cove lighting, and on all circuits which have a connected load in excess of 1,000 watts, No. 12 wire shall be used.

12. OUTLETS: Each switch, light, receptacle and other outlet through the building shall be provided with an outlet box of heavy metal. Outlet boxes inside of building shall be of the knockout type, and shall be set in such a manner as to be flush with the finished plaster. All outlet boxes outside of the building shall be of the marine water-proof type Crouse-Hinds condulet with rubber gaskets. All outlet boxes shall have only the open holes which are necessary to accommodate the conduits entering same. Outlet boxes in all cases shall be firmly fastened to the structure of the building.

13. DETAIL LOCATION OF OUTLETS: The location of the various outlets shown on the plans and mentioned in the specifications are only approximate and in order that all outlets shall come in proper relation to panels, pilasters, columns, etc., contractor shall study the details of these spaces, obtaining the necessary information from the ornamental plasterer and other contractors on the building, so as to make all the electrical work fit the work of the other contractors. In all cases, outlet boxes shall come in the center of the decorating panels, where same occur, so as to avoid any changing of outlets or decorating effects. In case any of the electrical contractor's work is not properly placed to the approval of the architect, this contractor shall move same without additional expense to the owner. All ceiling and bracket outlets for the attachment of fixtures shall be equipped with fixture supports firmly fastened to the outlet boxes and the structure of the building.

14. OUTLET ACCESSORIES: Where called for in these specifications for equipping outlets with sockets, switches, etc., contractor shall use only association made devices. For drop cords, contractor shall

furnish an Edison Key Socket, Loxon Lamp guard and reinforced cable, installing same in the outlet box cover having a bushed opening. Where flush switches are called for, contractor shall use G. E. No. 953 Tumbler. Where flush receptacles are called for, Cutler-Hammer Company's No. 7711 shall be used. Furnish steel covered receptacles, P. & S. No. 443, for all light outlets except where fixtures or drop lights are specified. Some of the outlets have special equipments and are mentioned further in these specifications. Lamps will be furnished by others, but lamping up shall be included in this contract.

15. FUSES: The contractor shall furnish a complete set of fuses for all fuse openings in the building. Plug fuses shall be used for lighting-branch circuits of 30 amp. or less capacity, and cartridge fuses for all feeders, sub-feeders, mains and sub-mains and all circuits of over 30-amp. capacity. All *National Electrical Code* fuses shall be Buss or D & W non-refillable.

16. DISTRIBUTION OF WIRING: The wire and conduit shall be run from cabinet to cabinet in the proper manner forming a chain of distribution, starting from the point of service entrance to the main distribution cabinet, then branching out from that point to all of the cabinets following. From the cabinets and switchboards, the wiring shall be run to the final points of distribution consisting of all light and power outlets, arc receptacles, sign outlets, etc. In distributing the wire to the lighting outlets from the above fuse cabinets, contractor shall group the outlets for such circuits in a consistent manner, placing not more than twelve (12) incandescent-lamp outlets, or 660 watts, on one branch circuit. For the borders, footlights and proscenium strips all trough and cove lighting, also canopy lighting, 1,320 watts may be placed on one branch circuit. Thirty-two aisle lights may be placed on one branch circuit.

17. CONTROL OF CIRCUITS: The lights in general spaces throughout the building shall be controlled from the various fuse centers either by master switches or separate circuit switches as described later. In some of the rooms, lights are to be controlled by flush switches, which are to be placed so as to be visible from the light which is being operated. The location of the switches is as shown on plans.

18. EMERGENCY AND EXIT SYSTEMS: The emergency system consists of all lights, indicated on the plans as "E," (see illustrations) which are used to illuminate the house while the show is going on. The emergency lights in the auditorium, aisle lights, lights at each exit door, lights in foyer, corridors, stairways, courts and other portions of the theatre to which the public has access, shall be connected to a separate cabinet "E," known as the emergency cabinet. This cabinet is to be fed by a separate feeder. There are several "service" circuits on the stage, in the basement and in the front portion of the building. These must be run so as to cut in ahead of all main switches on the various cabinets and to draw current through proper fuses in a manner that will allow these

circuits and lights to be used with the main switches, in the cabinets, open. Special mention of these circuits is made hereinafter.

19. BRANCH CIRCUIT LIGHTING CABINETS: All branch circuit lighting cabinets shall be flush or wall mounting as noted, and shall be constructed of code steel, provided with concealed hinge doors with Yale locks and masterkeyed, and all shall have a standard side wiring gutter. All branch circuit lighting panels shall be safety type with safety type switches in the mains and sub-mains. Bus bar work shall be satin finish. Branch circuit buses shall be of Edison Plug Fuse type, and each branch circuit shall be equipped with a No. 2645 Bryant panel board push switch placed under a sectional dead-front plate. Each switch shall have a card holder. Fuses and switches shall be in separate compartments.

20. MOTORS: All motors and starting devices will be furnished and delivered to the building by others, but this contractor shall receive and set same in place and make all necessary electrical connections. Provide a Trumbull, or equal safety type externally operated switch for each motor. This contractor shall include in his bid all necessary labor and material for connecting the motors complete ready to run. The remote control starter for organ motor is to be furnished by others.

21. SERVICE FUSING CABINETS—SWITCHBOARDS AND PANELS: There will be 17 principal switch and fuse cabinets in the theatre for the distribution of light and power. These 17 cabinets are as follows:

No. 1—Cabinet "A"—General-Lighting Cabinet for theatre lights.
No. 2—Cabinet "B"—Emergency Service Board for theatre emergency and exit lights.
No. 3—Cabinet "C"—General-Power Cabinet for theatre power.
No. 4—Cabinet "D"—Major Remote Board under stage.
No. 5—Cabinet "E"—Emergency cabinet.
No. 6—Cabinet "H"—Externally operated power switch for the converter.
No. 7—Cabinet "G"—Front door man's cabinet for general light in lobbys and foyer, etc.
No. 8—Cabinet "J"—Shop cabinet for all stores and shops.
No. 9—Cabinet "K"—Ditto for all offices and public lights.
No. 10—Cabinet "P"—Major Combination Pilot board and Dimmer Bank on the stage.
No. 11—Cabinet "O"—Picture Booth Cabinet for lights and small motors in booth.
No. 12—Cabinet "S"—Sign cabinet for theatre signs.
No. 13 to 17 inclusive—Five branch cabinets in 5 shops.

22. CABINET "A:" (Figs. 530 and 535) The main service will enter (X, Fig. 530) the building in the switchboard room which is located under

the stage as shown on the basement plan. Service wires and conduits to be brought to this cabinet, from the service Company's entrance (X, Fig. 530) in the alley, by the electrical contractor. The service wires (Fig. 550) to feed this main theatre lighting service, cabinet "A," shall consist of 6—600,000 C.M. cables. The service cabinet "A" shall be

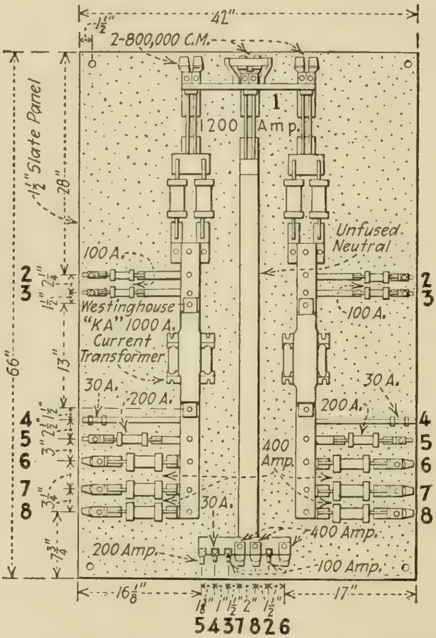


Fig. 535.—General-lighting cabinet—Cabinet "A"—for Indiana Theatre, Terre Haute, Ind. (*Frank Adam Electric Co.*) This is the shop drawing made by the switchboard manufacturer based on the electrical engineer's sketch, Fig. 551.

floor mounting and shall be constructed of No. 10 steel, the doors to be equipped with vault handles and plain hinges. Cabinet to have a standard side wiring gutter. Panel to be 1½-in. black electrical slate and contain the following (see Figs. 535 and 551):

Circuit No.	Description
1	1 1,200-amp., 110–220 volt N.E.C. fused service switch, with space for current transformer, feeding the following circuits.
2	1 100-amp., 3-pole, N.E.C. fuse connection, connected to bus behind the current transformers so that separate meter may be used, to feed Cabinet "J."
3	1 100-amp., 3-pole, N.E.C. fuse connection, connected to bus behind the current transformers so that separate meter may be used. Spare.
4	1 30-amp., 3-pole, N.E.C. fuse connection to feed the ½-h.p., 220-volt motor.
5	1 200-amp., 3-pole, N.E.C. fuse connection to feed Cabinet "G."
6	1 400-amp., 3-pole, N.E.C. fuse connection to feed Cabinet "S."
7 & 8	2 400-amp., 3-pole, N.E.C. fuse connections to feed the remote board, "D."

23. CABINET "B" (Figs. 530 and 555): The service-switch cabinet for the theatre emergency-and-exit lighting will be 100-amp., 3-pole, N.E.C. fused, safety-type, externally-operated switch, Trumbull, or equal, as approved by the architect. This switch is to be connected by 3 No. 6 wires in 1¼-in. conduit to a separate set of transformers so as to insure independent emergency lighting for all means of exit which are used by the public. This contractor shall run 3 No. 6 wires in a 1¼-in. conduit (Fig. 550) to cabinet "E" (Figs. 531 and 546) in doorman's closet in lobby.

24. CABINET "C" (Fig. 536): This is the general power cabinet and is to be located along side of Cabinet "A," (Fig. 530) and is constructed along similar lines. This cabinet will have a standard side wiring gutter. Feeders for this cabinet to be 4-2/0 cables in a 2-in. conduit from the

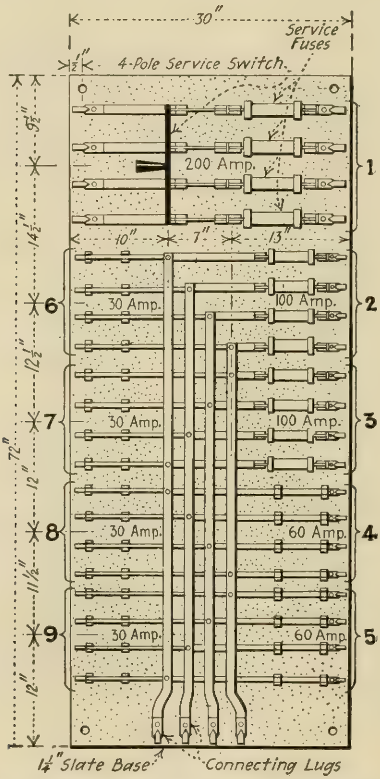


FIG. 536.—General-power cabinet—Cabinet "C"—for Indiana Theatre, Terre Haute, Ind. (*Frank Adam Electric Co.*) This is the shop drawing made by the switchboard manufacturer based on electrical engineers sketch, Fig. 552.

service company's entrance (Fig. 530) in the alley, supplying 440-volt, 2-phase alternating current. The panel for this cabinet (Fig. 536) will be 1½-in. black electrical slate, and shall contain (Fig. 552) the following:

Circuit No.	Description
1	1 200-amp., 4-pole, N.E.C. fused service switch, provided with necessary test links and meter loops.
2	1 100-amp., 4-pole, N.E.C. fuse connection to feed 30-h.p. typhoon fan.
3	1 100-amp., 4-pole, N.E.C. fuse connection to feed 25-h.p. heater fan.
4	1 60-amp., 4-pole, N.E.C. fuse connection to feed converter.
5	1 60-amp., 4-pole, N.E.C. fuse connection to feed 20-h.p. typhoon fan.
6	1 30-amp., 4-pole, N.E.C. fuse connection to feed organ motor.
7	1 30-amp., 4-pole, N.E.C. fuse connection to feed vacuum motor.
8	1 30-amp., 4-pole, N.E.C. fuse connection to feed 10-h.p. fan motor.
9	1 30-amp., 4-pole, N.E.C. fuse connection, spare.

25. METERING: Provision shall be made for the following meters:

1. One for total lighting load of the theatre, controlled by Cabinet "A."
2. One for the total power load of the theatre controlled by CABINET "C."
3. One for the emergency and exit lighting load of the theatre, controlled by Cabinet "B."

4 to 8. Five at Cabinet "J" for the 5 shops on 1st floor. See also Clause 46.

This contractor will bring out cables through required meter-fittings and provide a neat meter-board, painted black, for the accommodation of each meter. The meters will be furnished by others. The contractor shall confer with the representative of the local electric-service company and with the architect before deciding on the method of arranging the meters.

26. CABINET "P" PILOT BOARD ON THE STAGE (Figs. 537 and 553): The electrical contractor is to furnish and install complete a "Major" dead-front Pre-Selection system as manufactured by the Frank Adam Electric Company, St. Louis, Mo., consisting of a pilot-board "P" located on the stage as indicated on plans (Fig. 531), and a remote-board "D" in the basement under stage (Fig. 530) as shown.

The pilot-board (Figs. 537 and 553) shall be made up of the number of switch units as per schedule following (Clause 27), mounted on an angle-

iron frame enclosed in a steel cabinet made of No. 10 U. S. gauge steel. This cabinet shall be provided with a 4-in. mat of No. 10 steel. The upper part of the mat shall contain 3 No. 61,777 receptacles and three pear-shaped green shades (*A* and *I*, Fig. 537) for lighting the pilot-board.

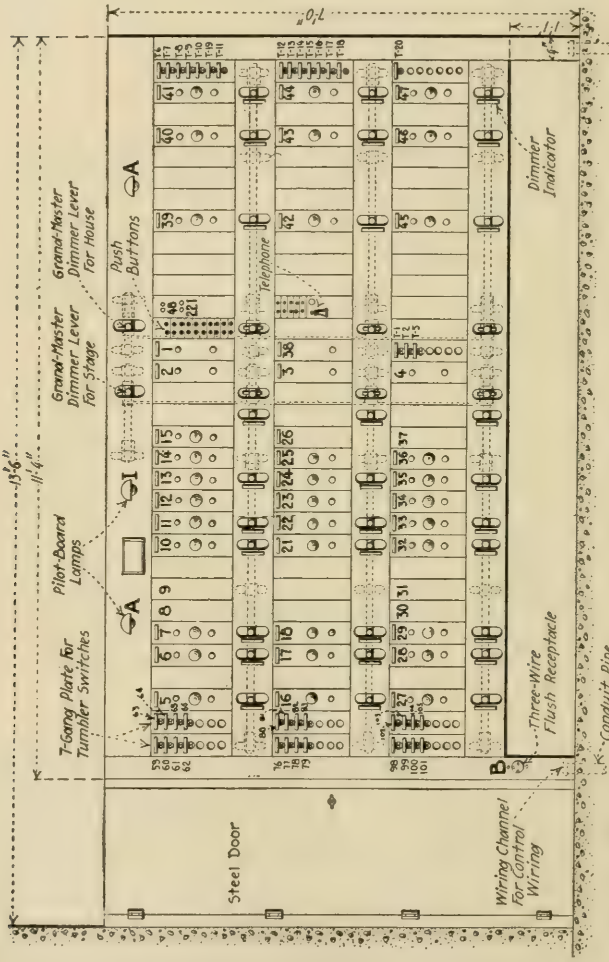


Fig. 537.—Front view of *Major* pilot board showing position of dimmer handles, for the Indiana Theatre, Terre Haute, Ind. (*Frank Adam Electric Co.*) This is the shop drawing made by the switchboard manufacturer based on electrical engineer's sketch, Fig. 553.

Two of these lights shall be controlled by a tumbler switch on the pilot-board, and one shall be so connected (Sec. 442) as to indicate whether the pilot board is dead or alive. The lower part of the mat shall be provided with a 3-wire flush receptacle, Bryant No. 425, (*B*, Fig. 537) complete,

with plug attached to one end of 50 ft., of 3-conductor, No. 14 stage cable, with a No. 2,642 Bryant Momentary contact push switch on the other end of the cable. This is to be so wired (Fig. 538) that the momentary-contact switch will control any or all pilot switches on the entire pilot-board, except those for the house lights.

There shall be 2 No. 2,642 Bryant momentary contact push switches, one located at the Door-man's Station (y, Fig. 531) and the other one on the front wall of the operating booth (x, Fig. 531) between look-outs. These switches shall be wired in multiple and connected to the house main by 3 No. 14 wires, to control all or any part of the lights in auditorium. Provide the necessary number of 7-gang plates (Fig. 537) and

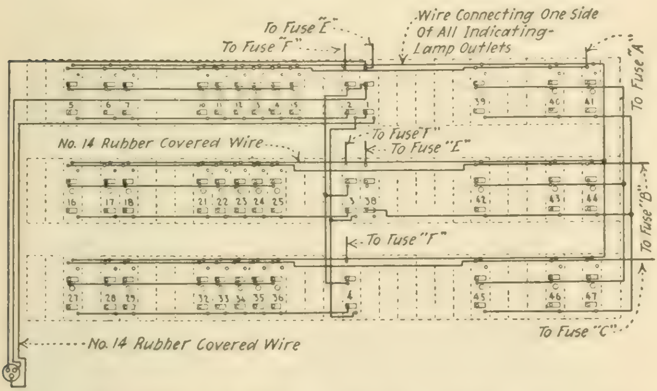


Fig. 538.—Wiring diagram of *Major* pilot board for Indiana Theatre, Terre Haute, Ind. (*Frank Adam Electric Co.*)

switches to provide a G. E. flush tumbler switch as per schedule (clause 28) under tumbler switches on Pilot Board. The tumbler-switch plates shall be the same gauge and finish as the pilot-switch plates. Each pilot-switch, except the masters, shall be provided with a pilot-light (Sec. 443) and color-cap corresponding with the colors of the lights controlled by the respective pilot-switches. This pilot-lamp shall be connected to the lamp-group controlled by the corresponding pilot-switch. Each pilot-switch shall be provided with an etched copper name-plate showing the name of the circuit controlled. Provide a special plate (Fig. 553) to take push buttons for calling dressing rooms.

The back of the pilot-board—magazine panels, Fig. 539—shall be made up of the required number of bus-bar fuse panels of 1-in. thick ebony asbestos, with a 4-in. removal strip of steel between adjacent panels. These panels shall be of the polarity type (Sec. 440) and shall have wire holes for mains and branch circuits. Provide angle lugs for attaching mains to bus. All branch circuits of capacities of from 1 to

30 amp. shall be of the Edison-plug-fuse type. All branch circuits of 30 amp. and over shall have N.E.C. fuses. Provide a name-plate for each branch circuit. This name-plate is to be located between bus-bars, and to be lettered as per instructions. The electrical contractor shall submit a detail shop drawing of these panels (see Fig. 539) for the architect or his electrical engineer's approval, before proceeding with this work.

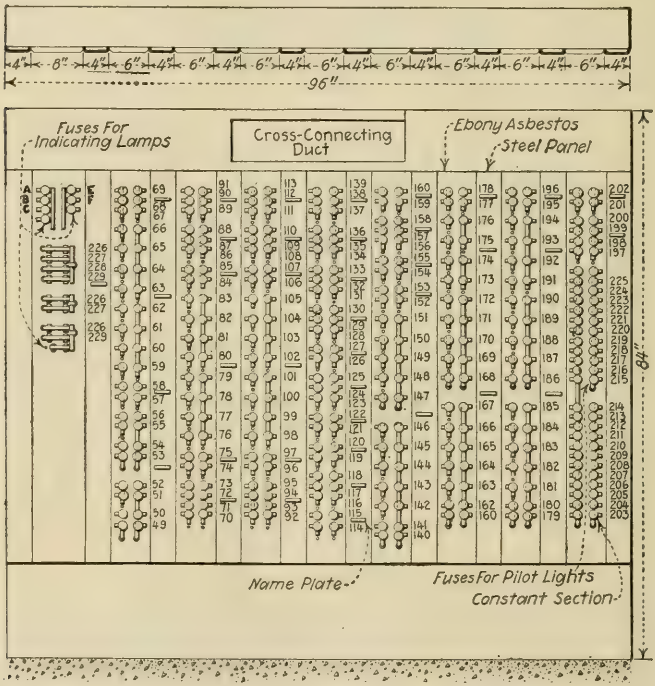


Fig. 539.—Magazine cabinet for the Indiana Theatre, Terre Haute, Ind. (*Frank Adam Electric Co.*)

In addition to the above pilot switches on the pilot board, there shall be 24 double-pole tumbler switches (Figs. 537, 540, and 553); one for each branch circuit of the red, white and blue incandescent stage pockets. Each tumbler switch is to be connected into the branch circuit between the magazine panel and the incandescent stage pocket outlet.

No. of Circuits	Circuit No.	Location of Lights Controlled	Load—Number of Watts and Type of Lamps	Total Watts	Dimmer (Individual Type Plate)	Total Dimmer Watts
		~ STAGE ~				
8	49 To 56	White Foots	150-60 Watt Mazda "B" Lamps	9000	G	9000
2	57 58	" Prosceniums (Platform Foots)	8-300 " " C " (30 60 W)	2400	A	2400
3	67 To 69	" Border No 1	12-300 " " C "	3600	B	3600
3	89 To 91	" " No. 2 (Future)				
3	86 To 88	" " No 3 (Future)				
2	84 85	" " No 4	8 300 " " C "	2400	A	2400
3	123 To 125	" Cradle Spots	3-1000 " " C "	3000	A	3000
2	121 122	" Balcony Floods	2 1000 " " C "	2000	None	
2	119 120	" Orchestra Spots	2 1000 " " C "	2000	C	
8	59 To 66	" Incandescent Stage Pockets	8 1000 " Receptacles	8000	C	8000
4	226 To 229	Arc Stage Pockets	4 35 Amp.	10000	None	
4	70 To 73	Red Foots	75 60 Watt Mazda "B" Lamps	4500	C	4500
2	74 75	" Prosceniums (Platform Foots)	8 300 " " C " (30 60 W)	2400	A	2400
3	137 To 139	" Border No. 1	12 300 " " C "	3600	B	3600
3	111 To 113	" " No 2 (Future)				
3	108 To 110	" " No 3 (Future)				
2	106 107	" " No 4	8 300 " " C "	2400	A	2400
3	116 To 118	" Cradle Spots	3 1000 " " C "	3000	A	3000
2	114 115	" Balcony Floods	2-1000 " " C "	2000	None	
2	159 160	" Orchestra Spots	2 1000 " " C "	2000		
8	76 To 83	" Incandescent Stage Pockets	8 1000 " Receptacles	8000	C	8000
4	92 To 95	Blue Foots	75 60 " Mazda "B" Lamps (30 60 W)	4500		4500
2	96 97	" Prosceniums (Platform Foots)	8 300 " " C "	2400	A	2400
3	134 136	" Border No 1	12 300 " " C "	3600	B	3600
3	131 To 133	" " No 2 (Future)				
3	128 To 130	" " No 3 (Future)				
2	126 127	" " No 4	8 300 " " C "	2400	A	2400
3	156 To 158	" Cradle Spots	3 1000 " " C "	3000	A	3000
2	154 155	" Balcony Floods	2-1000 " " C "	2000	None	
2	152 153	" Orchestra Spots	2-1000 " " C "	2000		
8	98 To 105	" Incandescent Stage Pockets	8 1000 " Receptacles	8000	C	8000
		~ HOUSE ~				
12	140 To 151	Amber Side Coves	64-200 " Mazda "C" Lamps	12800		12800
2	177 178	" Organ Grill Balustrades	10 250 " Type G30 Bulb Flood Lamp	2500	D	2200
4	173 To 176	" Behind Organ and Oriole Grills	112-40 " Mazda "B" Lamps	4480	E	4400
12	161 To 172	Red Side Coves	64-200 " " C "	12800		12800
2	195 196	" Organ Grill Balustrades	10 250 " Type G30 Bulb Flood Lamp	2500	D	2200
4	191 To 194	" Behind Organ and Oriole Grills	112-40 " Mazda "B" Lamps	4480	E	4400
12	179 To 190	Blue Side Coves	64-200 " " C "	12800		12800
2	201 202	" Organ Grill Balustrades	10-250 " Type G30 Bulb Flood Lamp	2500	D	2200
4	197 To 200	" Behind Organ and Oriole Grills	112 40 " Mazda "B" Lamps	4480	E	4400
5	A To F	Fuses for Pilot Switches	9 60 Amp. N.E.C. Circuits			
		~ CONSTANT CIRCUITS ~				
1	225	Switchboard Lights	4-25 Watt Mazda "B" Lamps	100		
		Work Lights in Border No. 1	1-300 " " C "	300		
1	224	" " " " No 2 (Future)				
		" " " " No 3 (Future)				
		" " " " No. 4	1-300 " " C "	300		
1	223	Rigging Loft	6 50 " " B "	300		
1	222	Orchestra Lights (8 Duplex Receptacles)	16 25 " " B "	400		
1	221	" Signal (Single Circuit M.C. Switch)	1 40 " " B "	40		
1	220	Stage Floor Lights	8 50 " " B "	400		
1	219	Upper Dressing Rooms	16 40 " " B "	640		
1	218	Fly Floor	6-50 " " B "	300		
		Attic Outlets	8 50 " " B "	400		
1	217	Property and Storage Rooms	4 100 " " B "	400		
1	216	Basement Passage	11 50 " " B "	550		
1	215	" Dressing Rooms	12 40 " " B "	480		
1	214	Chorus Room	2 300 " " B " (Future)	600		
1	213	Switchboard Room—Musicians and Animal Rooms	8 50 " " B "	400		
1	212	Heater Room Basement	12-40 " " B "	480		
1	211	" Plug	1-660 "	660		
1	210	Organ Lofts	8 50 " " B "	[illegible]		
1	209	Cleaner Outlet	1 1000 " " C "	[illegible]		
6	203 To 208	Spares				
	189 Plug Circuits	TOTALS		163490		134400
	13 N.E.C. Circuits					

Switch numbers totals: Pilot—Total 39; Tumb. & P.B.—Total 42, M.C.-2; Remote—Total 39.

NOTES AND OTHER DATA

Service 125/250 V., A.C., 3-Wire.

For Borders No. 2 and 3 provide spaces for 6 pilot and 6 remote switches and for 6-3600 watt dimmers, so that these can be installed later.

The plug fused circuits on magazine panels to be installed now.

Fuse "A" for 1st row pilot switches.
Fuse "B" for 2nd row pilot switches.
Fuse "C" for 3rd row pilot switches.
Fuse "E" for master pilot switches.
Fuse "F" for sub-master pilot switches.

FIG. 540.—Schedule of switches, fuses, circuits, dimmers, and control, on the stage switchboard of the Indiana Theatre, Terre Haute, Ind. (*Frank Adam Electric Co.*)

27. Schedule of Pilot, Magazine and Remote Switches and Dimmers

Pilot Sw. No.	Switches on pilot board "P": Controls	Switches on pilot board "P": No. of lamps and wattage of each	No. of magazine circuits	Switches on remote board "D"	Dimmers: Wattage.	Dimmers: Type
	Stage					
1	Stage main	No. 2 to 36	none	none	Main master	
2	White main	No. 5 to 15	none	S.P.	White master	
3	Red main	No. 16 to 25	none	S.P.	Red master	
4	Blue main	No. 27 to 36	none	S.P.	Blue master	
5	White foots	150 60-W.	8	3 P.	9,000	G
6	White prosc	8 300-W.	2	2 P.	2,400	A
7	White border No. 1	12 300-W.	3	2 P.	3,600	B
8	White space for border No. 2		3	space	space for 3,600 W.	
9	White space for border No. 3		3	space	space for 3,600 W.	
10	White border No. 4	8 300-W.	2	2 P.	2,400	A
11	White cradle spots	3 1,000-W.	3	2 P.	3,000	A
12	White balcony floods	2 1,000-W.	2	2 P.	none	
13	White orchestra spots	2 1,000-W.	2	2 P.	none	
14	White incandescent pockets	8 1,000-W.	8	3 P.	8,000	C
15	Arc pockets	4 35-Amp.	4	3 P.	none	
16	Red foots	75 60-W.	4	2 P.	4,500	C
17	Red prosc	8 300-W.	2	2 P.	2,400	A
18	Red border No. 1	12 300-W.	3	2 P.	3,600	B
19	Red space for border No. 2		3	space	space for 3,600 W.	
20	Red space for border No. 3		3	space	space for 3,600 W.	
21	Red border No. 4	8 300-W.	2	2 P.	2,400	A
22	Red cradle spots	3 1,000-W.	3	2 P.	3,000	A

23	Red balcony floods	2 1,000-W	2	2 P.	none	
24	Red orchestra spots	2 1,000-W	2	2 P.	none	
25	Red incandescent pockets	8 1,000-W.	8	3 P.	8,000	C
26	Blank					
27	Blue foots	75 60-W.	4	2 P.	4,500	C
28	Blue prosc	8 300-W.	2	2 P.	2,400	A
29	Blue border No. 1	12 300-W.	3	2 P.	3,600	B
30	Blue space for border No. 2		3	space	space for 3,600 W	
31	Blue space for border No. 3		3	space	space for 3,600 W	
32	Blue border No. 4	8 300-W.	2	2 P.	2,400	A
33	Blue cradle spots	3 1,000-W.	3	2 P.	3,000	A
34	Blue balcony floods	2 1,000-W.	2	2 P.	none	
35	Blue orchestra spots	2 1,000-W.	2	2 P.	none	
36	Blue incandescent pockets	8 1,000-W.	8	3 P.	8,000	C
37	Blank					
	House					
38	House main	No. 39 to 47	none	S.P.	Main master	
39	Amber side coves	64 200-W.	12	3 P.	12,800	6–B
40	Amber organ balustrades	10 250-W.	2	2 P.	2,500	B
41	Amber behind organ and oriole grills	112 40-W.	4	3 P.	4,480	E
42	Red side coves	64 200-W.	12	3 P.	12,800	6–B
43	Red organ balustrades	10 250-W.	2	2 P.	2,500	B
44	Red behind organ and oriole grills	112 40-W.	4	3 P.	4,480	E
45	Blue side coves	64 200-W.	12	3 P.	12,800	6–B
46	Blue organ balustrades grills	10 250-W.	2	2 P.	2,500	B
47	Blue behind organ and oriole grills	112 40-W.	4	3 P.	4,480	E
48	M. C. sw	Pilot board fuses	1	2 P.	none	

28. TUMBLER SWITCHES ON PILOT BOARD "P." In addition to the pilot switches shown in the foregoing schedule there are a number of tumbler switches on the pilot board (Fig. 537) which are fed by a constant section (Fig. 539) of the magazine panel at the rear of the pilot board. There shall be a total of 24-plug fuse circuits on magazine panel fed by 3 No. 6 wires from remote board "*D*." The tumbler switches (see Figs. 537 540 and 553) are for all outlets lettered "*T*" on plans and control the following:

T-1 Controls 1 10-watt and 3 60-watt lights (Fig. 537) on front and rear of pilot board. (Lamp *I*, Fig. 537) is connected as described in Sec. 442.)

T-2 and T-5 *Work lights:* Controls the 2 300-watt work lights (Fig. 533) in the center of each border light. (See border light specifications.)

T-3 and T-4 Omitted.

T-6 *Rigging loft:* Is a 3-way and controls 6 outlets (Fig. 532) above rigging loft. These outlets to be 8B boxes complete with cover sockets. These outlets are also controlled by a 4-way switch on fly floor, also by another 3-way switch in the rigging loft.

T-7 *Orchestra lights:* Is a 3-way and controls 8 duplex flush receptacles (Fig. 531) for orchestra stands. The other 3-way switch is at the leader's stand. Get the exact location of this switch from the Architect.

Note: This contractor shall furnish complete 10 Major type, or equal, approved music stands wired complete with 10 ft. of cable.

Note: (Switch No. 221, Figs. 537 and 540). This contractor shall also furnish and install complete to the orchestra pit a signal system as follows: 1 circuit from the constant buss on the rear of the pilot switchboard through a single circuit momentary contact push-switch (located on the pilot switchboard) to a cover socket, located under footlight trough in view of the leader of the orchestra.

T-8 Is a 3-way and controls 2 ceiling outlets with cover socket, also 6 wall outlets (Fig. 531) on side walls of stage complete with pull chain sockets and crescent wall guards. Note all the above outlets are also to be controlled by a 3-way switch at one stage entrance and a 4-way at the other stage entrance.

T-9 *Dressing rooms:* Controls 12 outlets in 4 upper dressing rooms (Fig. 533) also 4 outlets in passage ways and stairs to upper dressing rooms.

T-10 Controls 3 outlets (Fig. 532) on fly floor, also 3 outlets on stairway to fly floor and rigging loft. These outlets to be complete with cover sockets and crescent wall guards.

T-11 Controls 4 100-watt outlets (Fig. 531) in the property and storage space. These outlets to be complete with drop cords, key sockets and Loxon guards.

T-12 Is a 4-way and controls 10 outlets (Fig. 530) in basement passage ways, toilets, stair leading to basement, also one outlet (Fig. 531) outside over stage entrance. All to be complete with cover sockets,

except the ones over the stage entrance, and these shall have a goose neck of ½-in. conduit complete with a 14-in. R.L.M. Standard steel reflector.

T-13 Controls 12 40-watt outlets (Fig. 530) over make up tables in 4 dressing rooms in basement.
Note: All dressing room outlets to be 8B boxes with cover sockets, complete with crescent wall guards.

T-14 Controls 2 300-watt ceiling outlets (Fig. 530) in future chorus room.

T-15 Controls 8 outlets (Fig. 530) in switchboard room, musicians' room and animal room, all with drop cords complete as per T-11.

T-16 Controls 12 40-watt outlets (Fig. 530) in basement heater rooms. See note under T-11.

T-17 *Heater outlet:* Controls heater outlet (Fig. 530) in basement. This outlet to be complete with Bryant No. 558 Heater Control Combination.

T-18 Controls 8 50-watt outlets (Fig. 533) in organ lofts.

T-19 Controls 8 60-watt outlets (Fig. 532) in attice space and fan rooms. See note under T-11.

T-20 *Cleaners outlet:* Is a 3-way and controls 1 1000-watt outlet (Figs. 532 and 533) on the gridiron at the center line, 2 ft. behind the proscenium wall. This outlet to be complete by this contractor with an 18-in. standard R.L.M. steel reflector and mogul receptacle equipped with No. 14 stage cable of length to allow the reflector to be lowered within 5 ft. of the stage floor.

29. REMOTE BOARD PANEL "D:" This contractor shall furnish and install complete a Major Remote Control Board (Figs. 541 and 554) at position (Fig. 530) as indicated on plans. This remote board shall be made up of the required number of remote switch panels as per the preceding schedule (Clause 27). Each remote switch panel shall contain 1 100-amp. Cutler-Hammer Major special remote switch, with N.E.C. fuse connections of proper capacity for load. The remote switch panels shall have back connected studs, and be so connected (Fig. 542), to the main buss on the rear of the board, that both the remote switch and fuses will be dead when the switch is open. The remote switch panels shall be drilled for 30, 60 and 100 amp. N.E.C. fuse connections so that it will be possible to change fuse capacity to take care of future increases in the load. The entire remote board shall be inclosed in a No. 10 gauge steel cabinet with both front and rear access doors. This cabinet shall be placed so as to be accessible from both front and rear.

30. SCHEDULE OF REMOTE SWITCH CONTROLS FROM PANEL "D" (Fig. 541):

D-2 White Main controls remote switches No. 5 to 15 inclusive.

D-3 Red Main controls remote switches No. 16 to 25 inclusive.

D-4 Blue Main controls remote switches No. 27 to 37 inclusive.

D-5 *Footlights:* White Foots controls 150 60-watt lamps fed from 8 branch circuits (Nos. 49 to 56, Fig. 539) on the rear of pilot switch-

board. These circuits to be brought to a pull-box located below the stage floor, at the end of the trough near the pilot switchboard. Connections between the trough and pull-box are to be made with Greenfield Flexible conduit, so that the trough can be removed for cleaning without disturbing any connection. Reflector and lining of gutter to be furnished by others. Footlights to have 150 White,

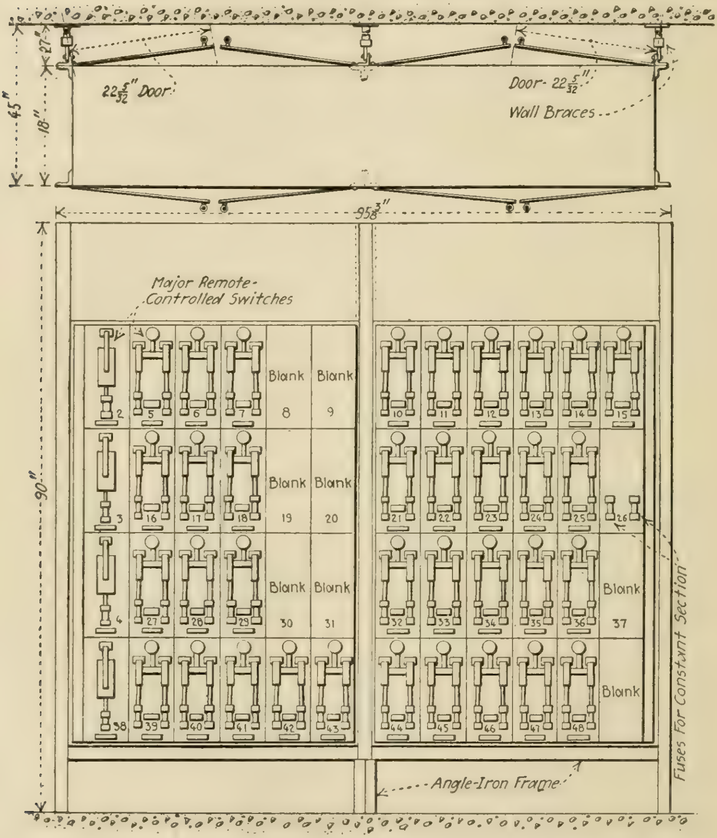


Fig. 541.—Front view of remote board with doors removed, for the Indiana Theatre, Terre Haute, Ind. (*Frank Adam Electric Co.*) This shows the switchboard manufacturers shop drawing.

75 Red, and 75 Blue lights, all of which are 60 watt. The reds and blues shall be in the upper row, and the whites in the lower. The lights shall be wired on alternate circuits (Fig. 529) all the way across the trough. Use No. 12 D.B.R.C. wire for the wiring of the footlights. For detail of footlights see Fig. 543.

D-6 *Proscenium strips:* White proscenium strips right and left controls 8 300-watt lamps (Fig. 531) fed from 2 branch circuits (Nos.

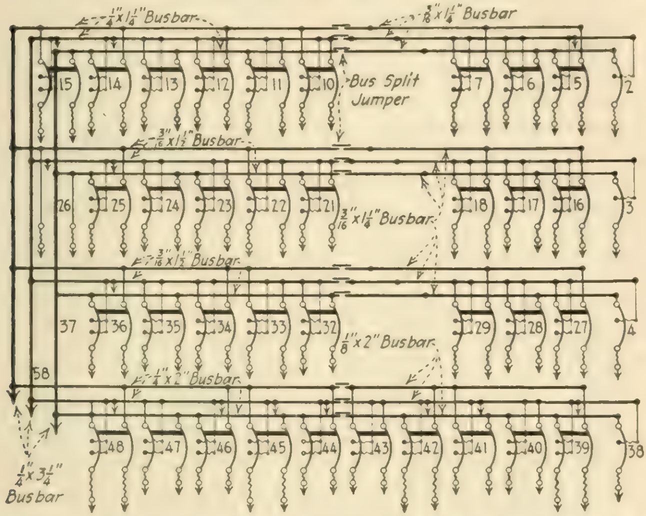


FIG. 542.—Wiring diagram of the *Major* remote board for the Indiana Theatre, Terre Haute, Ind. (*Frank Adam Electric Co.*) This diagram is furnished by switchboard manufacturer.

57 and 58, Fig. 539) on the rear of the pilot switchboard. Furnish and install two "Major" type proscenium strips. These strips

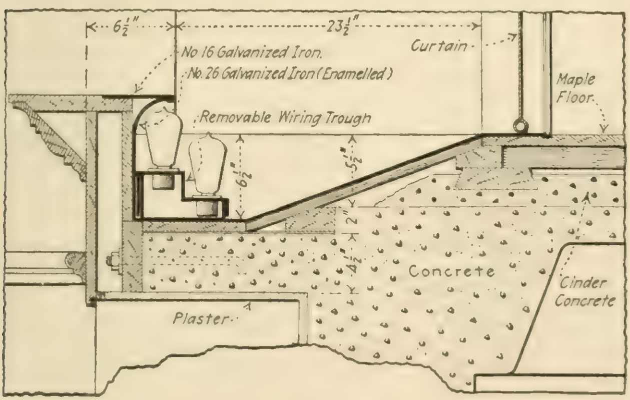


FIG. 543.—Section showing detail of footlights.

shall be constructed similar to borders, wired for 3 colors for each strip, one circuit for each color, with 4 300-watt type C-lamps

per circuit. This contractor shall furnish 24 color frames for the two proscenium strips. Each strip shall be 16 ft. long. Each lamp shall be in a separate compartment with suitable groove for receiving color slide or frame. These grooves to be the same size as the grooves in the borders, so that the frames for the borders and prosceniums will be interchangeable. These strips to be equipped with a heavy wire mesh guard hinged at one side and provided with a catch at the other side. Guards to be made in two sections, mesh to be approximately 1¼-in. square. Prosceniums shall be located as shown on plans (Fig. 531) and shall be painted same as the borders.

Note by Author.—Inasmuch as this Terre Haute theatre is, for the present to be used as a moving picture-house only, the proscenium strips are omitted. A platform or miniature stage has been built on the stage. This platform is provided with a footlight trough which is to contain outlets for 90 60-watt lamps. They are called (Fig. 540) *platform foots.* These 90 outlets are wired on three colors as follows: 30 white, 30 red, and 30 blue. The lamps of each color are fed from the two magazine circuits which, according to the original specifications, were intended to feed the proscenium strips. Thus, if at any future time, it is desired to use the house for vaudeville or "legitimate," the proscenium strips may be provided at a minimum expense.

D-7 *Border lights: White border* No. 1 controls 12 300-watt lamps (Fig. 533) fed from 3 branch circuits (Nos. 67 to 69, Fig. 539) on the rear of the pilot switchboard. This contractor shall furnish complete 2 "Majorlite" borders. These borders shall be constructed of No. 20 gauge iron, equipped with mogul receptacles G.E. No. 159,380 and wired with No. 12 Underwriters' "slow burning" wire, see *Code* Rule 38*e*, par. 6. Each lamp shall be in a separate compartment with suitable groove for receiving color slide or frame. Lamps are to be spaced on 12-in. centers. Each border shall be wired for three colors. Border No. 1 shall have 36 300-watt Mazda *C* lamps, 12 white, 12 red and 12 blue. Border No. 4 shall have 24 300-watt Mazda *C* lamps, 8 white, 8 red and 8 blue. This contractor shall furnish 60 color frames for the two borders. In addition to the above circuits there shall be a separate circuit run to the center of each border to feed a 300-watt work light. This light is to be controlled by a tumbler switch located on stage switchboard. Four of these work lights may be placed on one circuit, but a separate tumbler switch must be provided for each light.

Border No. 1 shall be 37 ft. long. Border No. 4 shall be 25 ft. long. This contractor shall install necessary chain hangers and giant strain insulators and border light cable for each border. Borders shall be painted two coats aluminum inside, and two coats dull black outside. Steel cable, counter weights and all other rigging furnished by others. In the rigging loft the contractor shall install 2 large pull boxes of 10 circuits each, located 10 ft. off center, each to take care of connections to the magazine panel on rear of pilot switchboard. The pull boxes shall have bushed opening for bringing out border light cables which shall be fastened to the box in such

a manner so as to take the strain from the connection to the circuit wires. Border light cables shall feed border at its center and shall be of length to allow borders to come within 5 ft. of the stage floor. Border Nos. 3 and 4 and wiring for same to be omitted. Also omit pilot and remote control switches and dimmers for same, but arrange space so they can be installed in future.

D- 8 *White border* No. 2. Blank.

D- 9 *White border* No. 3. Blank.

D-10 *White border* No. 4. (Same as white border No. 1 except to be 25 ft. long with 24 300-watt lights on 3 colors.)

D-11 *Cradle spots:* There will be a cradle (Fig. 544) or swinging bridge furnished by others but this contractor shall furnish and install all necessary electrical connections for 9 1,000-watt spot outlets on

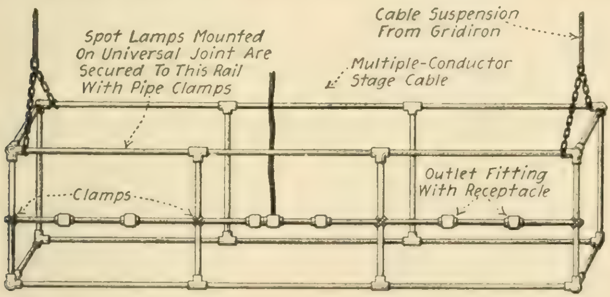


FIG. 544.—Cradle for cradle spots. (A board floor is laid on bottom of cradle.)

this cradle installed in the following manner: 3 1,000-watt outlets are to be switched on D-11; 3 1,000-watt outlets on D-22; and 3 1,000-watt outlets on D-33. This contractor shall install a pull box (Fig. 533) flat on the rigging loft at point as indicated on the plans. From this pull box hang 1 18-conductor, No. 12 border-light cable of sufficient length to allow the cradle to be lowered to the stage floor. This cable to feed into a pull box on the rail of the cradle, and from there to 9 10-amp. No. 7711 flush receptacles mounted equal distances apart all the way across the rail of the cradle using conduit and condulets.

D-12 *Balcony floods: White balcony floods*—furnish 6 1,000-watt balcony flood lamps with color frames on three colors, white, red and blue, and install 6 10-amp. flush receptacles (Fig. 533) in the front wall of the operating room above the ledge for attaching 6 1,000-watt nitrogen spot lights. These outlets to be wired for 3 colors, with 2 outlets per color. Use C. H. Co.'s, No. 7711 flush receptacle. Confer with architect for exact location of these outlets.

D-13 *Orchestra spots: White orchestra spots*—furnish 6 1,000-watt orchestra spot or flood lamps with color frame. Furnish and

install 6 10-amp. flush receptacles (Figs. 533 and 534) above main ceiling, one at each of the rectangular openings. These outlets are to be equipped as per outlets under D-12 and are for 1,000-watt spots.

D-14 *Stage pockets: White incandescent stage pockets*—controls 8 15-amp. receptacles fed from 8 branch circuits (Nos. 59 to 66, Fig. 539) on the rear of the pilot board. Contractor shall furnish and install, where shown on plan (Fig. 531) 8 stage pockets, three on each side of the stage and two in the rear of the stage. Four (4) of these pockets shall have 1 35-amp. arc, and 3 15-amp. incandescent receptacles, and four (4) shall have 3 15-amp. incandescent receptacles to be Kliegl, Major, or equal, as approved by the architect. These stage pockets shall be set flush in the stage floor and shall be provided with steel frames. The steel frames shall be insulated from the conduit system. Contractor shall furnish a total of 4 arc plugs and 24 incandescent plugs for these pockets. Feeders to each arc receptacle shall be No. 6, D.B.R.C. wire, and to each incandescent No. 12 wire.

D-15 *Stage arc pockets*—controls 4 35-amp. arc receptacles fed from 4 60-amp. N.E.C. fuse circuits (Nos. 226 to 229, Fig. 539) on the rear of the pilot switchboard.

D-16 *Red foots*—controls 75 60-watt lamps fed from 4 branch circuits (Nos. 70 to 73, Fig. 539) on the rear of the pilot switchboard (see detail of footlights, Fig. 543).

D-17 *Proscenium strips (red) right and left*—controls 8 300-watt lamps (Fig. 531) fed from two branch circuits on the rear of the pilot switchboard (see note under D-6.)

D-18 *Red border* No. 1—controls 12 300-watt lamps (Fig. 533) fed from three branch circuits on the rear of the pilot switchboard.

D-19 *Red border* No. 2. Omitted.

D-20 *Red border* No. 3. Omitted.

D-21 *Red border* No. 4 (see D-10).

D-22 *Red cradle* (see D-11).

D-23 *Red balcony floods*, same as D-12.

D-24 *Red orchestra spots*, same as D-13.

D-25 *Red incandescent pockets*—controls 8 15-amp. receptacles fed from 8 branch circuits on the rear of the pilot switchboard.

D-26 Omitted.

D-27 *Blue foots*—controls 75 60-watt lamps fed from 4 branch circuits on the rear of the pilot switchboard (see Fig. 543).

D-28 *Blue proscenium strips right and left*—controls 8 300-watt lamps fed from 2 branch circuits on the rear of the pilot switchboard (see note under D-6).

D-29 *Blue border* No. 1—controls 12 300-watt lamps fed from 3 branch circuits on the rear of the pilot switchboard.

D-30 *Blue border* No. 2. Omitted.

D-31 *Blue border* No. 3. Omitted.

D-32 *Blue border* No. 4 (see D-10).

D-33 *Blue cradle* (see D-11).

D-34 *Blue balcony floods,* same as D-12.

D-35 *Blue orchestra spots,* same as D-13.

D-36 *Blue incandescent stage pockets*—controls 8 15-amp. receptacles fed from branch circuits on the rear of the pilot switchboard.
Note: There shall be one tumbler switch located on the pilot switchboard for each of these receptacles.

D-37 Blank.

D-38 Auditorium main, controls switches Nos. 39 to 47.

D-39 *Side wall coves: Amber*—Controls 64 200-watt lamps (Fig. 534) fed from 12 branch circuits on the rear of the pilot switchboard. This contractor shall furnish and install complete 192 X-Ray No. 610 reflectors for 200-watt lamps placed on 12-in. centers in the two side wall coves and arranged on three-color wiring. The reflectors to be complete with holders, sockets and wire troughs. There will be 64 200-watt lamps for the amber, 64 200-watt lamps for the red, and 64 200-watt lamps for the blue. This contractor shall furnish 192 color frames and color screens for the auditorium coves.

D-40 *Organ grill balustrades: Amber*—Controls 10 250-watt lamps (Figs. 533 and 534) fed from 2 branch circuits on the rear of the pilot switchboard. This contractor shall furnish and install complete 30 X-Ray, No. 800, projector reflectors for 250-watt lamps, placed in the two organ ballustrades, arranged on three-color wiring. The reflectors to be complete with color screen holders and color lenses, also sockets and holders. There will be 10 250-watt lamps for the amber, 10 250-watt lamps for the red, and 10 250-watt lamps for the blue. These to be arranged for flood lighting the proscenium arch and organ grills.

D-41 *Behind organ and oriole grills: amber*—Controls 112 40-watt lamps (Figs. 533 and 534) fed from 4 branch circuits on rear of pilot switchboard. This contractor shall furnish and install complete approximately 104 ft. of trough reflectors of various lengths to fit behind the art glass of the above places. There will be eight 10-ft. sections for placing behind the art glass plaques at either side of the organ grills. There will be 4 6-ft. sections for placing behind the art glass plaques at the two orioles. Each reflector shall be wired for three colors with 40-watt lamps on 4-in. centers. Furnish detail drawings of these reflectors for architect's approval. Install 312 40-watt lamps on three colors in the side wall plaques, grills and orioles. There are to be 112 40-watt lamps for the amber, 112 40-watt lamps for the red, and 112 40-watt lamps for the blue. The three colors are to be alternated the full length of each trough reflector.

D-42 *Controls red,* same as D-39.

D-43 *Controls red,* same as D-40.

D-44 *Controls red,* same as D-41.
D-45 *Controls blue,* same as D-39.
D-46 *Controls blue,* same as D-40.
D-47 *Controls blue,* same as D-41.
D-48 *Controls feeders* to magazine circuits "A" to "H" inc., for fusing pilot board.

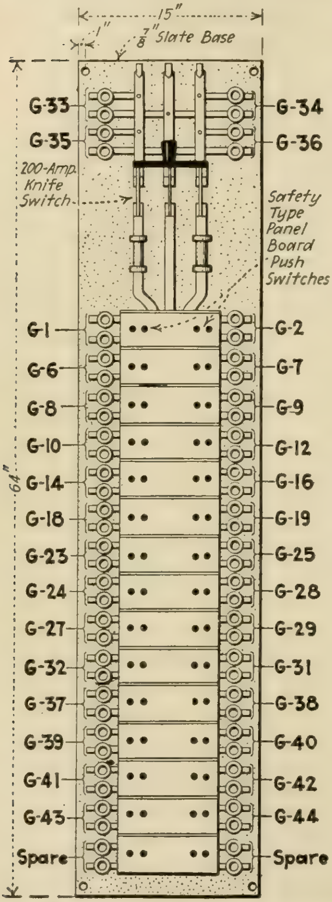


FIG. 545.—Front doorman's cabinet—Cabinet "G"—for Indiana Theatre, Terre Haute, Ind. (*Frank Adam Electric Co.*) This shows the switchboard manufacturer's drawing.

31. CABINET "G"—FRONT DOORMAN'S OR LOBBY CABINET: This cabinet (Fig. 545) is for all lights (except emergency and sign) in the front portion of the building and is located in the doorman's closet (Fig. 531) as indicated on plans. This cabinet is to be wall mounted and shall contain a bus bar type panel with a 100-amp. no fuse knife switch for the mains and safety type push switch for all circuits under 20 amp. The fuses for the branch circuits shall be in a separate compartment. Each switch shall be provided with a card holder. This cabinet is to be connected to circuit No. 5 in Cabinet "A" by 3 No. 0 wires in a 2-in. conduit.

Note: Circuits G-33 to G-36 are not switched and must be placed ahead of main switch.

32. SCHEDULE OF CONTROLS—CABINET "G":

G-1 and G-2 Controls 2 1,320-watt circuits to center ceiling outlet (Fig. 533) in rotunda. Fixture by others.
G-3, G-4 and G-5. Omitted.
G-6 Controls 4 150-watt bracket outlets (Fig. 532) on side walls of upper part of rotunda.
G-7 Same as G-6.
G-8 Controls 2 300-watt bracket outlets (Fig. 531) on side walls of promanada.
G-9 Same as G-8.
G-10 Controls 1 1,000-watt floor outlet (Fig. 531) on promanada.
G-11 Omitted.
G-12 Same as G-10.
G-13 Omitted.

G-14 Same as G-10.

G-15 Omitted.

G-16 Same as G-10.

G-17 Omitted.

G-18 Controls 15 40-watt soffitt outlets (Fig. 531) in promanada.

G-19 Same as G-18.

G-20 to G-22 Omitted.

G-23 Controls 4 100-watt outlets (Fig. 531) on ceiling of promanada.

G-24 Controls 4 150-watt base plug outlets (Fig. 531) in the promanada.

G-25 Controls 6 100-watt base plug outlets (Fig. 531) in the promanada.

G-26 Omitted.

G-27 Controls 6 100- and 1 50-watt outlets (Fig. 533) in screening room.

G-28 Controls 2 300-watt outlets (Fig. 531) for newel posts on stairs in promanada.

G-29 Controls 8 75-watt outlets (Fig. 531) in ceiling over fountain.

G-30 Omitted.

G-31 Controls (Fig. 531) 2 50-watt outlets in men's toilet, 6 50-watt outlets in ladies parlor and toilet, 1 50-watt base outlet in ladies parlor, and 1 100-watt ceiling outlet in ladies parlor.

G-32 *Signs:* Controls 6 25-watt sign outlets (Fig. 531) over doors. This contractor shall furnish and install complete 6 No. 19,424 Polaralite signs made by I. P. Frink Company. These signs to have the following lettering; "Balcony," "Check Room," "Ladies Parlor," "Smoking Room," "Aisle 1," "Aisle 2," and baby spot in promanada ceiling.

G-33 Feeds 6 60-watt, ceiling outlets (Fig. 531), and 4 60-watt base plugs in box office.

G-34 Feeds 1 60-watt outlet in doorman's closet, 1 60-watt outlet in Check Room, 1 60-watt outlet in Janitor's closet, 1 60-watt outlet in Advertising Room, 1 60-watt outlets in ushers' room. All these outlets to be drop cords. Also 4 60-watt ceiling outlets and 1 60-watt base plug outlet in Manager's Office.

G-35 Feeds Cabinet "*O*" (Fig. 531)in operator's booth with 2 No. 12 wires.

G-36 1000-watt machine outlet (Fig. 533) in screening room.

G-37 to G-42 Controls 64 100-watt outlets (Fig. 533) in the cove in upper part of the rotunda.

G-43 Controls 4 150-watt outlets (Fig. 534) on ceiling over balcony, For cleaners' outlets.

G-44 Same as G-43.

33. CABINET "E"—EMERGENCY CABINET: Cabinet "E" (Fig. 546) is the emergency cabinet and is located (Fig. 531) along side of Cabinet "G." This cabinet and panel to be constructed similar to Cabinet "G," and shall have a 100-amp. main line remote-controlled switch (Fig. 546), not fused, with safety-type push switches in the branches. This cabinet is connected to the emergency switch cabinet

"B" by 3 No. 6 wires in an 1¼-in. conduit. This remote switch is controlled from the momentary-contact switch (Fig. 531) in the rotunda.

34. SCHEDULE OF CONTROLS FROM CABINET "E":

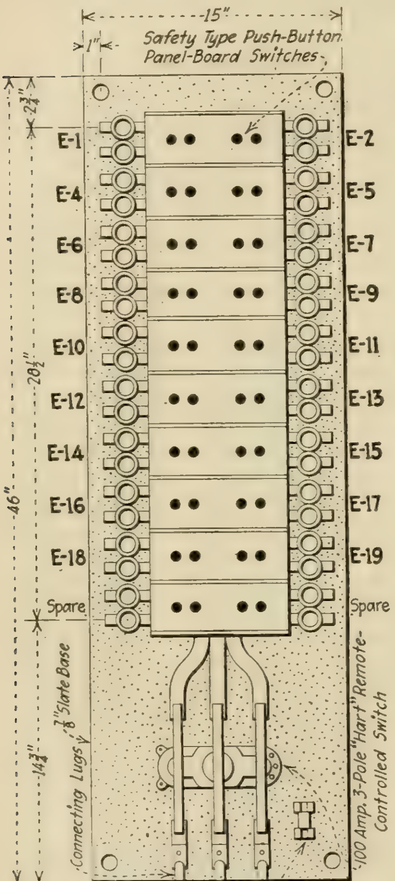


Fig. 546. — Emergency cabinet — Cabinet "E"—for Indiana Theatre, Terre Haute, Ind. (*Frank Adam Electric Co.*)

E-1 Controls 4 150-watt bracket outlets (Fig. 531) on the lower portion of the side walls of the rotunda.

E-2 Controls 5 150-watt bracket outlets (Fig. 531) on the lower portion of the side walls of the rotunda.

E-3 Omitted.

E-4 Controls 2 300-watt bracket outlets (Fig. 531) on pilasters in promanada.

E-5 Same as E-4.

E-6 Same as E-4.

E-7 Controls 6 100-watt ceiling outlets (Fig. 531) in passage ways leading to promanada.

E-8 Controls 6 100-watt outlets (Fig. 531 and 533) on stairs to balcony.

E-9 Controls 8 60-watt side wall bracket outlets (Figs. 531 and 533) in auditorium.

E-10 Same as E-9, except on opposite side.

E-11 Controls 14 50-watt outlets (Fig. 533) on main ceiling over rear of balcony.

E-12 Controls 8 50-watt bracket outlets (Figs. 531, 532 and 533) on emergency stairway to balcony.

E-13 Controls 7 50-watt bracket outlets (Figs. 531, 532 and 533) on stairs to balcony.

E-14, E-15, E-16 *Aisle Lights:* Control 88 10-watt outlets (Fig. 533) for aisle lights. This contractor shall furnish and install complete 62 Brookins Aislelites and 26 flush cabinet aisle lights with glass covers.

These flush cabinet fixtures with glass covers are to be installed in boxes, lamps, stairs, and on partitions.

E-17 Controls 22 10-watt inside exit lights (Figs. 531 and 533). Contractor to furnish EXIT boxes, sockets, and art glass signs.

E-18 Controls 14 25-watt outside exit lights (Figs. 531 and 533). Each outlet to be water proof.

E-19 Controls 5 100-watt ceiling outlets in promanada.

E-20 Omitted.

35. CABINET "S"—SIGN CABINET: This cabinet (Fig. 547) is of special construction and is shown on Fig. 556 attached here-

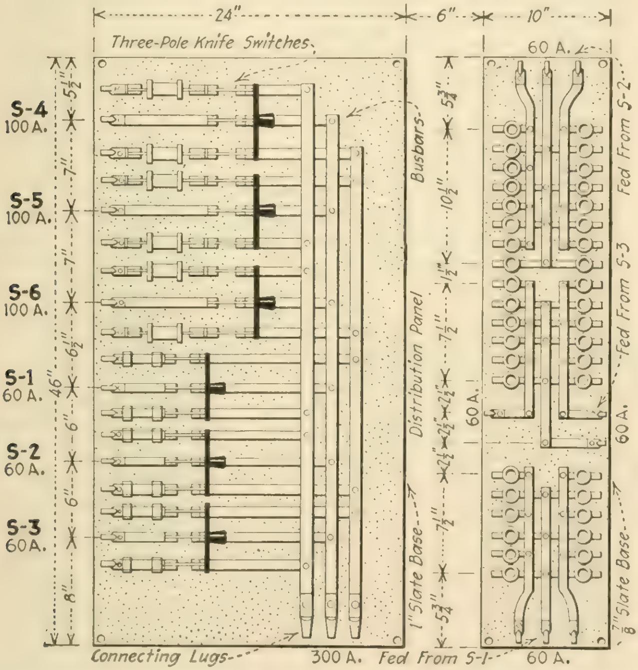


Fig. 547.—Sign cabinet—Cabinet "S"—for Indiana Theatre, Terre Haute, Ind., (*Frank Adam Electric Co.*)

with and which forms a part of these specifications. Cabinet "S" is located in (Fig. 531) closet above Cabinet "E" and is of special construction. Feed Cabinet "S" from Cabinet "A" with 3 300,000 C.M. cables in 2½-in. conduit.

36. SCHEDULE OF CONTROLS FROM CABINET "S":

S-1 *Cornice lights:* Is a 3-pole, 60-amp. standard knife switch feeding 6 branch circuits for 68 75-watt lamps (Fig. 533) in soffitt of cornice. This contractor shall furnish and install these outlets

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complete. Confer with contractor for terra cotta, and with the architect for the method of installation.

S-3 *Canopy lights:* Is the same as S-1 but it feeds 6 branch circuits for 99 75-watt outlets (Fig. 531) in inside section of canopy.

S-4 *Main sign:* This is a 100-amp. 3-pole knife switch feeding 3 No. 1 wires to roof, where flasher box will be installed by others.

S-2 *Canopy lights:* Same as S-1 feeding 8 branch circuits for 132 75-watt outlets (Fig. 531) around edges of canopy. This contractor shall furnish and install 17-A boxes with P & S cover sockets for all canopy outlets.

S-5 *Attraction sign on canopy:* Same as S-4 feeding 3 No. 4 wires for sign on front edge of canopy.

S-6 *Future sign:* Same as S-4 feeding 3 No. 2 wires to an outlet over canopy at center of building for future sign.

37. CABINET "H" IN OPERATING ROOM: Cabinet "H" is a 4-pole, 60-amp., N.E.C. fused, safety-type, externally-operated knife-switch located in operating room (Fig. 531).

38. PICTURE BOOTH—CABINET "H": This switch is to be fed by 4 No. 8 wires in a 1-in. conduit from fuse connection No. 4 of cabinet "C" (Fig. 536) and is to feed the motor generator. The motor-generator set and panel will be delivered to the building by the owners, but this contractor shall receive same, set it in place, and make all necessary electrical connections. From the panel furnished with motor generator set, the contractor shall run $1\frac{1}{4}$-in. conduit and 2 No. 4 wires to each picture machine. These conduits shall run through the concrete floor and turn up 24 in. from the front wall of the booth on the center of the projection opening. Furnish type "A" condulet with 2-hole cover located 3 in. above the floor. The No. 4 wires in each conduit shall be long enough to extend to switch terminals on machines without splicing. At the same location, contractor shall install a $\frac{1}{2}$-in. conduit with 2 No. 14 wires from Cabinet "*O*" for the motors on the picture machine, these conduits to run to the 4-circuit Cabinet "O."

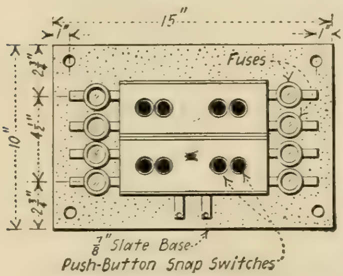

FIG. 548.—Panel for picture booth cabinet—Cabinet "O"—for Indiana Theatre, Terre Haute, Ind. (*Frank Adam Electric Co.*)

39. CABINET "*O*:" Fuse panel Cabinet "*O*" (Fig. 548) on the wall of the booth (Fig. 531) is for booth lights and motors on picture machines and rewind. This cabinet is fed by 2 No. 12 wires (see G-35) from Cabinet "G." Contractor shall install a flush push switch controlling a flush receptacle at the location of the rewind shelf for the rewind motor. From this same cabinet the contractor shall install a push switch at the door to control 3 drop-cord outlets, located over the head of each

machine, and one over the rewind shelf, also 1 outlet in vestibule and 1 in converter room. These drop cords to be equipped with porcelain sockets and guards with cords long enough to reach within 3 ft. of the floor. Install 2 No. 6 wires in a 1-in. conduit run from the motor generator panel through the floor of the booth to a point on the front wall of the booth 18 in. above the floor under the spotlight opening. Furnish a 2-hole type "A" condulet. The owners will deliver to the building three

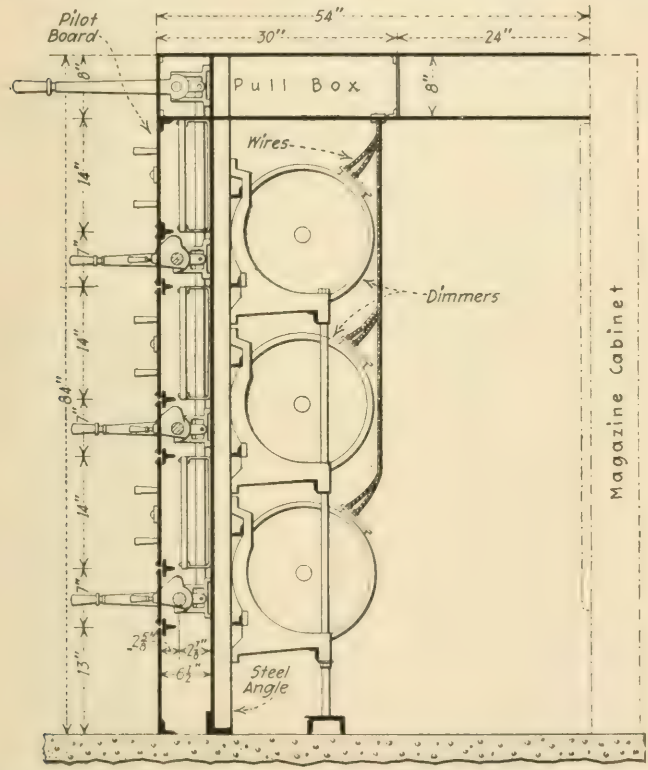

FIG. 549.—Side view of pilot board for Indiana Theatre, Terre Haute, Ind., showing location of dimmers, pull-box and magazine cabinet. (*Frank Adam Electric Co.*)

picture machines and one spotlight. This contractor shall receive same, set them in place and make all necessary electrical connections.

40. DIMMERS: This contractor shall furnish and install 1 bank of Cutler-Hammer Interlocking 110-step theatre dimmers, equipped with a slow motion cross interlock lever-shaft drive, arranged as in Fig. 537, construction for mounting at the rear (Fig. 549) of the pilot board (Fig. 531) on the stage. Each dimmer lever is to have an indicator

attachment. Plates to be arranged 3 high with the master levers in the center of the bank. Dimmers to be of the wattage as per schedule under pilot board, Clause 27 and Fig. 540. The house dimmers shall be designed for continuous duty.

41. TELEPHONE SYSTEM: This contractor shall furnish and install complete in an operating condition 12-station system, location of stations as follows:

1. Manager's office, combination set (Fig. 531).
2. Operator's booth, combination set (Fig. 531).
3. Box office, combination set (Fig. 531).
4. Main doorman, flush type wall phone (Fig. 531).
5. Balcony tunnel telephone, flush type as directed (Fig. 533).
6. Balcony tunnel telephone, flush type as directed (Fig. 533).
7. Musicians' room, wall type (Fig. 530).
8. Screening room, wall type (Fig. 533).
9. Pilot board on blank panel, combination set.
10. Orchestra leader, combination set (Fig. 531).
11. On pilaster in promanada, flush type (Fig. 531).
12. Office No. 6, combination (Fig. 532).

These telephones shall be of the Stromberg-Carlson make and shall be of the inter-communicating type with selective ringing and common talking lines. Provide a bell ringing transformer for the ringing for these telephones, and a Patterson Battery set for the talking side. Provide buzzers for all combination telephones. Others shall have bells. Provide lead covered telephone cable, installed in ¾-in. conduit for the above telephones.

42. CONDUITS FOR PUBLIC TELEPHONES: This contractor shall install proper conduit and pull boxes for the public telephone systems as used in Terre Haute providing outlets (Fig. 531) as follows: One outlet in the box office; one outlet in the manager's office, and one outlet in each of the public telephone booths (Fig. 531) in the lobby. Conduit only to be installed by this contractor.

43. DRESSING ROOM CALLS: There shall be furnished and mounted on Pilot switchboard (Fig. 553) a series of 20 push buttons for operating the call bells (Fig. 530) in each dressing room, the help's room, musicians' room, property room and animal room. A bell-ringing transformer shall be installed for operating the bells. All wires for this system shall be lead-covered installed in conduit as specified under telephones.

44. STORES, OFFICES, SHOPS AND STORE ROOMS: This contractor shall install all necessary wiring for the stores, offices, and shops, in the theatre building, including switches, flush receptacles, etc., all ready for the attaching of the fixtures and ceiling fans. The ceiling fan outlets will not be on any switch. There will be a separate cut-out and switch cabinet in each of the five shops (Fig. 531) under this contract. These cut-out cabinets will be located as shown on electric plan (Fig. 531). These will be of the flush type, steel construction with mat

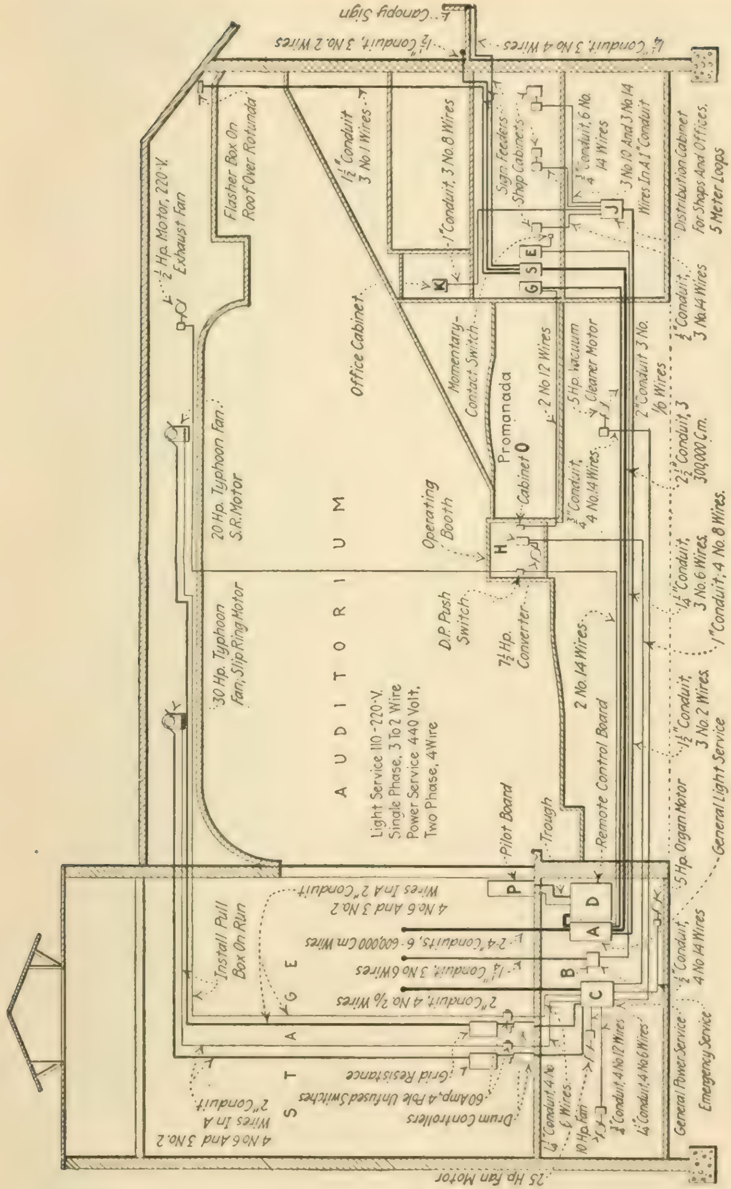

FIG. 550.—Feeder diagram for Indiana Theatre, Terre Haute, Ind. (Pierce Electric Co.)

and door, having porcelain cut-outs of the number as shown on plans, inside the cabinet with push button switches in the steel mat of the cabinet for control of lights in each shop.

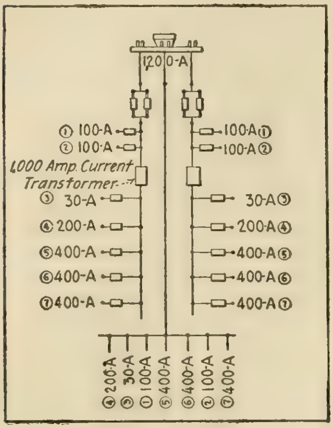

FIG. 551.—Panel for cabinet "A." Electrical engineer's sketch included in specifications. See Fig. 535 for shop drawing.

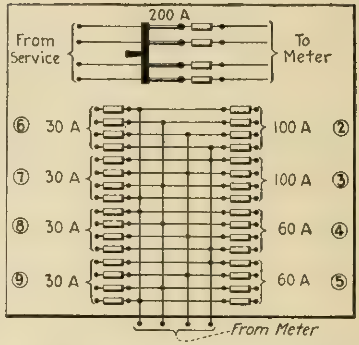

FIG. 552.—Panel for general-power cabinet—cabinet "C." This sketch accompanies architects specifications.

45. CABINET "J": This cabinet will be located in the passage of the basement (Fig. 530) under the shops on 7th St., as shown on the

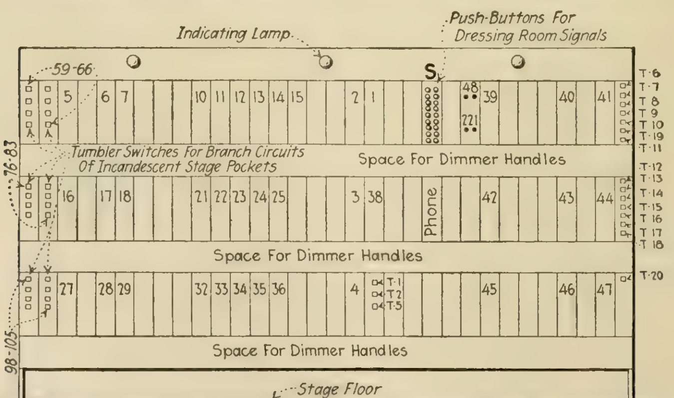

FIG. 553.—Electrical engineer's sketch of pilot board, "P"—included in the specifications for wiring the theatre.

electric plan. This cabinet will be wall mounting, having a slate panel on which will be mounted 1 200-amp. non-fused main line switch, 5 30-amp., N.E.C. fused, branch circuits for the five stores, 1 60-amp.,

branch fuse connection for Cabinet "K," and 1 60-amp. fuse, spare. This cabinet will be fed by 3 No. 2 wires in 1½-in. conduit from Cabinet "A."

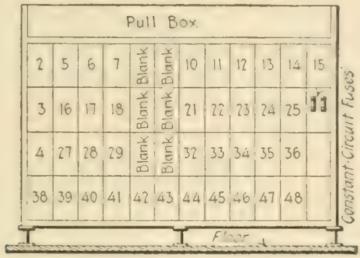

FIG. 554.—Remote board "D." Electrical engineer's sketch accompanying specifications.

46. CABINET "K": This cabinet feeds all "K" outlets in all offices, and also public lighting lettered "K-1" to "K-4." This cabinet will be

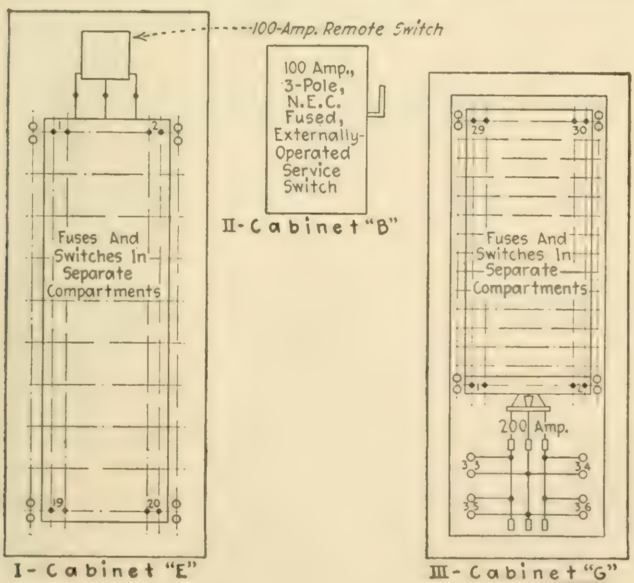

FIG. 555.—Cabinets "E," "B" and "G."

located (Fig. 532) in the janitor's closet on the 2nd floor as shown on the electric plan, and will contain 14 circuits arranged for separate metering of the 7 offices and 1 meter for the 4 circuits for the public lighting. All

wiring to the offices will be complete by this contractor, ready for the fixtures which will be furnished by others. This cabinet is fed by 3 No. 8 wires from Cabinet "J."

47. CABINETS AND SWITCHBOARD DIAGRAMS: Attached to these specifications are four blue prints (Figs. 550, 551, 552, 553, 554, 555 and 556) showing the diagramatic arrangement of all panels and switch boards on this job. Each outlet on the plan is keyed with a letter and numberal indicating which switch in the various cabinets the outlet

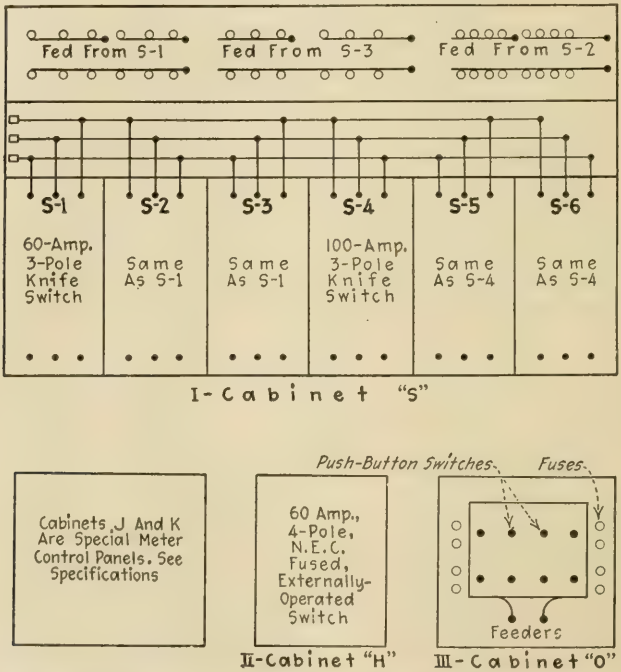

FIG. 556.—Cabinets "S," "H" and "O." Sketch accompanying specifications.

is controlled from. To wit: Outlet "G"-10 is controlled by switch No. 10 in Cabinet "G."

48. GUARANTEE: All material and workmanship shall be of the best kind and must meet with the approval of the owner and architect, who reserve the right to reject any material not in accordance with these specifications either before or after installation. Drawings of cabinets and lay-outs must be submitted to the architect also actual samples of wire which is to be used before they are either contracted for or purchased by the electrical contractor.

QUESTIONS ON DIVISION 9

1. Name four principal requirements which should be considered in laying out the circuits for lighting a theatre.

2. What two types of construction are used for theatre service wires? What conditions determine which type is preferable?

3. Name the three separate services with which theatres are usually provided. Under what conditions may the general-power service sometimes be dispensed with?

4. Name the two services which a theatre *must* have. What determines the wire-size for each?

5. What is the function of the *general-power service?* What motors in the theatre are not generally fed by the general-power service?

6. What is the function of the *emergency service?*

7. What are *emergency lamps?*

8. Why is it desirable that the emergency service and the general-lighting service be connected to different street mains? Where it is impractical to do this, what other methods of connecting the emergency service to the source of supply may be used? Make a diagram to illustrate each method.

9. When a storage-battery energy-supply is provided for the emergency service, what method is frequently used to connect the regular emergency-service line and the storage-battery system to the emergency-circuit feeder? Make a diagram to illustrate.

10. Why is trouble more likely to occur on the general-lighting service than on the emergency service?

11. Make a sketch of a non-interchangeable arc-and-incandescent stage pocket and explain why either plug will only fit its own receptacle.

12. What is the function of the *general-lighting service?* What lamps receive energy from this service?

13. By what type of current and at what voltage is the energy for lighting a theatre usually delivered? That for driving the motors of a theatre?

14. With what must each *service* be equipped? How must the service switch and service fuses be wired? How should they be mounted?

15. What *type of service fuses* is generally used for capacities less than 800 amp.? What kind of protection is usually provided when the capacity is greater than 1,000 amp.?

16. What is a *service board?* Where are the service boards for a theatre usually located? Why?

17. Why is it sometimes undesirable to locate the service boards in the stage-basement? Make a sketch to illustrate.

18. Make a diagram to illustrate the general scheme of the circuit-layout which is ordinarially used for theatres.

19. Of what does the *general-power cabinet* usually consist? Under what conditions may the general-power cabinet be located at some point which is remote from the service entrance?

20. From what is the converter panel fed?

21. Of what does the *emergency service board* usually consist?

22. Why are the emergency service board and the emergency distribution panel not usually combined?

23. Define *emergency cabinet*. Of what does this cabinet usually consist? Why is it advisable to omit the switches in the branch circuits of the emergency cabinet.

24. Where should the emergency cabinet be located? Why?

25. What two types of main switches are generally used in the emergency cabinet? When a remote-controlled main switch is used to control the emergency cabinet, where is the controlling momentary-contact switch usually installed?

26. What is the purpose of the *emergency lamps?* About what wattage per square foot of floor space is generally required to accomplish this purpose?

27. What lamps are on the emergency circuit?

28. How many sets of fuses can any emergency lamp have between it and the main emergency-service fuses?

29. Explain why the exit-sign lamps are not, strictly speaking, considered to be emergency lamps.

30. Of what does the *general-lighting cabinet* usually consist?

31. Name the distribution centers or cabinets which are ordinarily fed from the general-lighting cabinet.

32. Where is the *sign cabinet* usually located? Under what conditions may it be installed in a different location? What types of switches are used in sign cabinets? When the sign cabinet is remote-controlled, where are the controlling-momentary-contact switches usually installed?

33. By what other name is the *front-doorman's cabinet* sometimes called? Where is it nearly always located? Of what does it consist? What lights are fed from this cabinet? What lights should be connected ahead of the main switch in this cabinet? Why?

34. Of what does the *picture-booth cabinet* generally consist? Where is it located? From what cabinet is it fed? What energy-consuming devices does it serve?

35. Explain how a profitable current-saving may sometimes be effected by properly selecting the circuits to which the lamps in the front portion of the theatre are connected?

36. Under what conditions is a *dressing-room cabinet* used? From what is the dressing-room cabinet fed? What lamps does it serve? When a dressing-room cabinet is not used, where is the distribution center for the lamps which it ordinarily serves?

37. For what purpose is a *shop cabinet* used? From what cabinet is it fed? Explain two methods of metering the energy which passes through the shop cabinet.

38. From what is the *stage switchboard* fed? What lights are generally controlled by the stage switchboard?

39. Define: (*a*) *House lights.* (*b*) *Stage lights.* (*c*) *Work lights.* What are the lamp-colors which are generally used for the house and stage lights? In what proportions are these colors generally installed?

40. Define the following terms: (*a*) *Remote-control switchboard.* (*b*) *Remote board.* (*c*) *Pilot board.* (*d*) *Individual pilot switch.* (*e*) *Sub-master pilot switch.* (*f*) *Master pilot switch.*

41. Define and make a sketch to illustrate each of the following: (*a*) *Switchboard feeder.* (*b*) *Stage-main switch.* (*c*) *House-main switch.* (*d*) *Color-main switch.* (*e*) *Magazine switch.* (*f*) *Magazine subfeeder.* (*g*) *Magazine panel.* (*h*) *Magazine circuit.*

42. Draw a sketch to illustrate the general scheme of circuit control as is provided on stage switchboards.

43. Name the principal requirements of stage switchboards. What is probably the most necessary requirement?

44. Where is the stage switchboard usually located? Why?

45. What kind of stage switchboard is required by the Code?

46. What is meant by a *manual stage switchboard?* A *remote-control stage switchboard?*

47. Theoretically, what two methods of remote control of stage switchboards may be employed? Which type is used in practice?

47. Give the classification of manually-operated, dead-front stage switchboards. Define each class? Explain how each is operated.

48. Explain how the similarity in control between interlocking and non-interlocking switchboards is obtained.

49. What is the function of a *grand-master lever* on an interlocking, manually-operated switchboard? Of *pre-set master levers.*

50. Make a sketch to illustrate the relative location of the dimmers, switchboard and magazine panel. What other arrangements are sometimes used?

51. What is the ampere rating of the smallest size magazine switch that is generally used on a stage switchboard?

52. Name one of the principal types of remote-control stage switchboards.

53. Name the advantages of the *Major Pre-Selective Control System.*

54. Define *pre-selective control.*

55. Name the two essential elements of the Major system.

56. In the Major system, where may the dimmers be mounted?

57. Describe the operation of the remote-controlled switch that is used in connection with the Major system.

58. Make a sketch of and explain the operation of the *Major pilot switch.* Draw a symbolical wiring diagram of the Major pilot switch.

59. Name the two switches contained in a Major pilot switch, and explain why each is so named.

60. Make a sketch of a single lamp-group which is controlled by a remote-controlled switch and a pilot switch to show the circuit diagram. Explain its operation.

61. Draw a circuit diagram of six remote-controlled switches, which are controlled by six individual pilot switches. Also show how two sub-master pilot switches are connected so that each will control three of the individual pilot switches; and a master pilot switch to control the entire group. Explain the operation.

62. When is a single-pole sub-master remote-controlled switch used for an alternating-current system? For a direct-current system. Why is it necessary to provide this single-pole sub-master remote-controlled switch. Explain by example. Show by sketch how two such switches would be connected into the installation, a sketch of which was drawn in Question 61.

63. Classify the switches on a Major pilot board and tell what the switches of each classification control.

64. How are the stage pilot switches connected? The house pilot switches?

65. What type of switch is employed on the Major board to control the work lights?

66. Define *polarity-type distribution panel.* Make a sketch of a three-wire polarity panel. Make a sketch of a two-wire polarity panel. What is the advantage of a polarity panel over that of an ordinary panel?

67. Draw a sketch to illustrate two methods, which are used in the Major system, of connecting the magazine circuits to the remote-board busbars. Why is it sometimes desirable to connect a two-pole magazine switch as a three-pole switch with a solid neutral?

68. Show by sketch how the Major pilot board is fed.

69. Explain how the Major system may be electrically "locked." Draw a sketch to illustrate.

70. Show by diagram how a lamp may be connected to indicate whether the pilot board is "dead" or "alive."

71. Show by sketch how the indicating lamps on the individual pilot switches are connected.

72. What pilot switches are not provided with indicating lamps? Why?

73. Make a sketch to show how all of the stage and house lights may, in the Major system, be controlled by a two-circuit momentary contact switch. Explain the utility of this feature.

74. What are theatre *dimmers?* Into what part of the circuit are they connected? Explain how dimmers are operated.

75. Give the Code requirement relating to the method in which dimmers must be wired. Draw sketches to illustrate two methods of complying with this requirement.

76. What is the maximum wattage rating of a single dimmer plate? How is a lamp-load greater than this maximum wattage dimmed? Make a sketch to show the correct method of connecting two or more dimmer plates to dim one lamp-group. Make a sketch of an incorrect method. Explain how this incorrect method may result in burning out all of the dimmers in the unit.

77. What is the general rule to be followed in fusing the stage-switchboard circuits?

78. Make a diagram to illustrate a method which is sometimes employed in wiring the footlights. Explain the utility of this method.

79. Draw a feeder diagram for the electric wiring of a theatre. Show the location of the service entrances, and the location of all cabinets, panel boxes and switchboards.

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